DIY BEAST: APC's 12TH GEN BUILD

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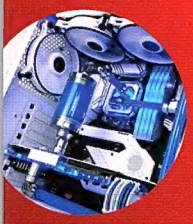

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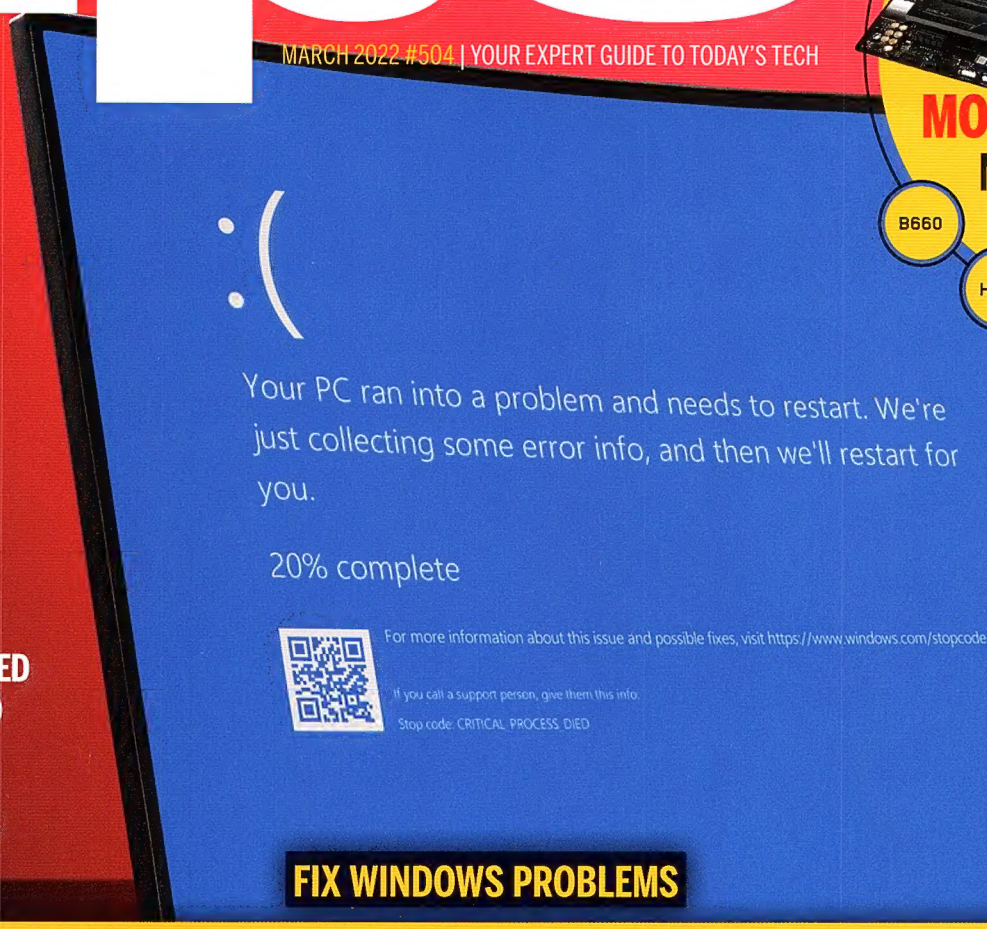
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Your PC ran into a problem and needs to restart. We're just collecting some error info, and then we'll restart for you.
20% complete
For more information about this issue and possible fixes, visit https://www.windows.com/stopcode
If you call a support person, give them this info:
Stop code: CRITICAL_PROCESS_DIED

FIX WINDOWS PROBLEMS

SAVE YOUR SYSTEM

• BOOT ISSUES SOLVED • RECOVER LOST FILES • REPAIR A BAD INSTALL
• CLEAR UPDATE GLITCHES • BSODs BE GONE • FIX FREEZES
• COMMON ISSUES QUASHED

>> HOW-TO
GRAPH YOUR DISK USAGE

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POTENT & PORTABLE: MSI GE76 STEALTH

SWEET SPOT CPU: INTEL i5-12400

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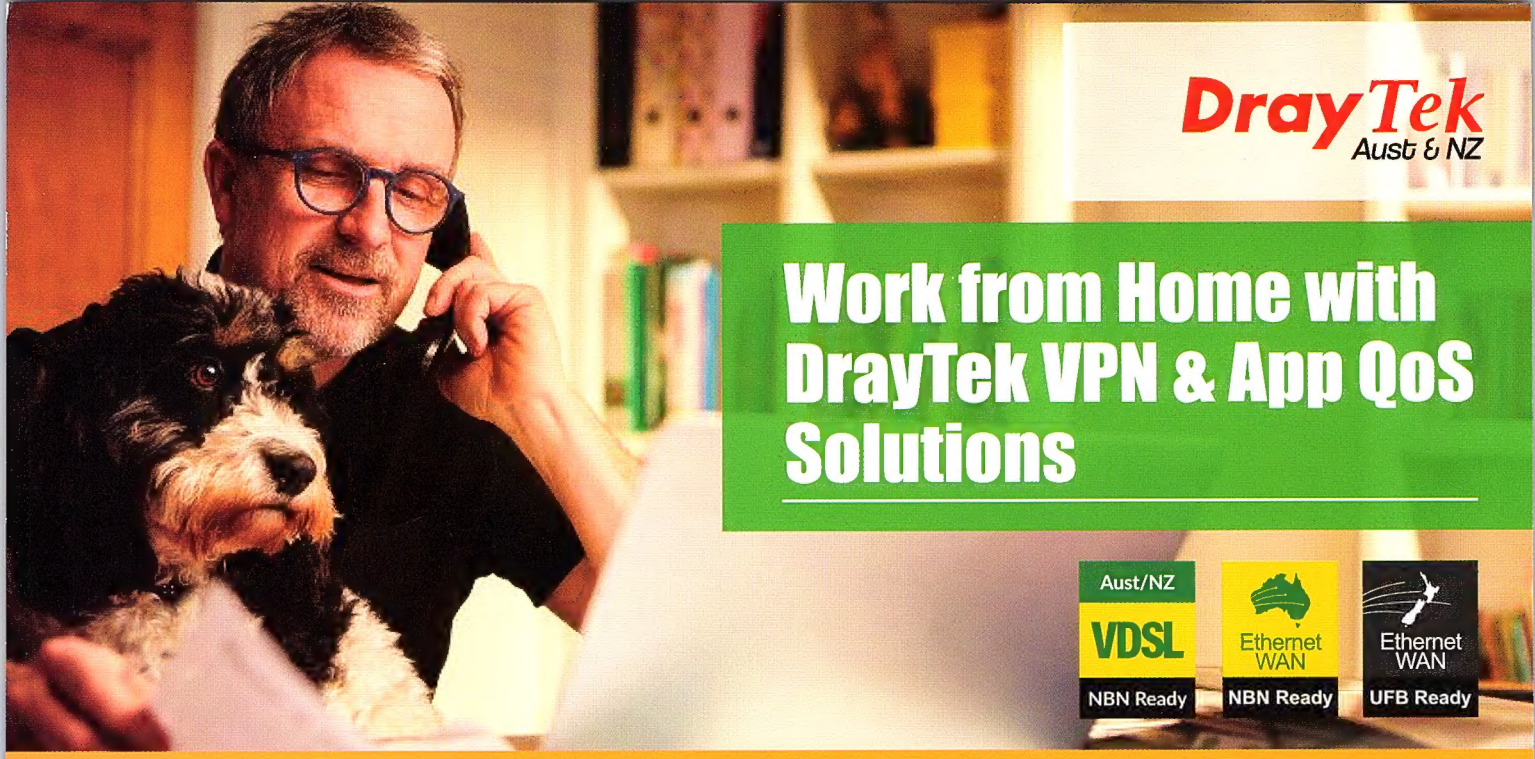

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EDITORIAL

WHAT'S INSIDE *APC*

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If you call a support person, give them this info:
Stop code: CRITICAL_PROCESS_DIED

BEN MANSILL
Used to think that 'real computing' solely meant sitting at a desk in front of a screen.

EDITORIAL

Be borked no more

APC's Windows problem-solver guide is here.

Awards time is almost upon us! As you read, the editorial team is debating the great many products we saw through 2021, and from all the many worthy finalists picking winners. Every important PC category is covered – we are examiningCPUs, motherboards, graphics cards, systems and laptops, peripherals and components, plus the super-special Excellence and Gold awards.

All will be revealed in the next issue of *APC*, so it's a special one to grab. We'll be covering all the good stuff that was released in Australia through 2021, and it's always an honour for us to be able to acknowledge the talent at the many companies that provide us all with the gear we love.

In other rather exciting news, we've also been examining ways of improving *APC* for you, and starting next month we have some very cool new regular sections making their first appearance. It's also a good time to trim back on some areas I don't think are necessarily the best use of our pages. We're not doing a massive overhaul, but I do think that the new content we're adding makes for an excellent monthly read, so see what you think when the next issue comes out (around March 21st), and see for yourself. Of course I am always ears-open – so there's plenty of opportunity to let me know your thoughts.

Until then, do please enjoy this issue of *APC*. Our cover story is a Windows problem fixing guide, and it's the sort of thing you'll want to keep handy if and, sorry to say, when, disaster strikes. So do file this one away, it's a keeper.

If producing any kind of digital audio has interested you – whether it's music, a podcasts or anything else – we have several lovely features to help, and that includes looking back at the evolution of digital audio over time.

Plus, for anyone about to hit the 'add to cart' button for a new Intel-based system, Chris has summarised the new motherboard chipsets on offer, because it can be not just confusing, but also potentially expensive if you unwittingly end up paying for features you'll likely never use.

Until next month!

Our cover story is a Windows problem fixing guide, and it's the sort of thing you'll want to keep handy if and, sorry to say, when, disaster strikes. So do file this one away, it's a keeper.

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Your free full-version apps as a thanks for reading *APC*. These exclusive downloads will only be available for a limited time, from 21/02/22 to 10/04/22.

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Clean and accelerate Windows PCs.

Over time, Windows tends to slow down and become cluttered due to leftover files and Registry entries. Ashampoo WinOptimizer 2022 is a customisable Windows cleaner and accelerator. Privacy protection is another focus of the program, with the ability to significantly limit telemetry and data collection by Microsoft. Don't just accept the Windows defaults! Ashampoo WinOptimizer 2022 includes a total of 23 modules to boost and customise Windows systems. The program also analyses your OS and hardware, wipes or encrypts data and helps with file recovery.

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ASHAMPOO HOME DESIGN 6

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Ashampoo Home Design 6 enables users to design, furnish and visualise their dream home, extension or redecoration on their PCs. The project wizard combined with multiple automatic features helps users get started quickly and greatly facilitates complex calculations. The extensive object catalog covers everything from furniture to electrical appliances and decorations. Every aspect of construction planning is covered. The impressive 3D view supports virtual tours to survey buildings already in the planning phase. Ashampoo Home Design 6 comes with professional-quality walls, ceilings, windows, doors, recesses, skylights, solar panels, chimneys as well as electrical appliances. Three design levels (2D, 3D, cross-section) provide maximum clarity at every planning step.

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intel CORE | intel CHIPSET Z690 | DDR5 | PCIe 5.0 | Windows 11 Ready | WiFi 6

*Specification vary by model.

ASUS

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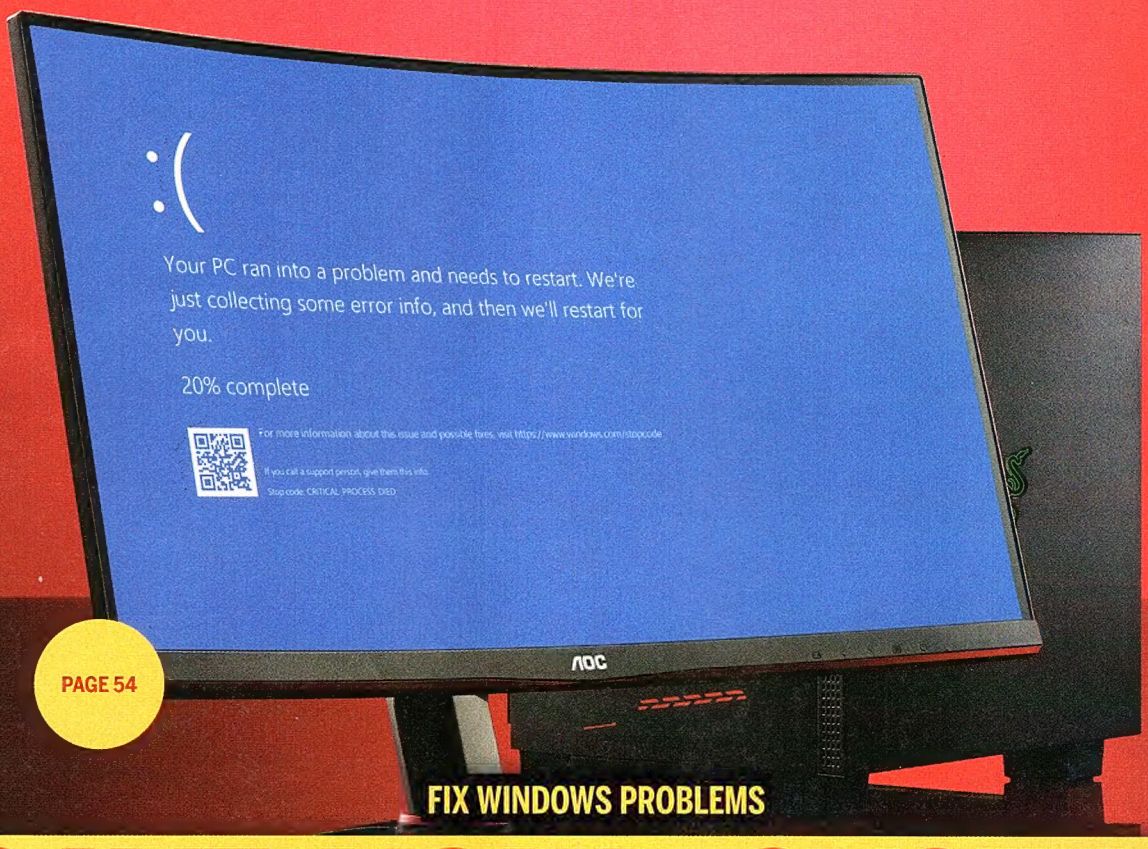
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SAVE YOUR SYSTEM

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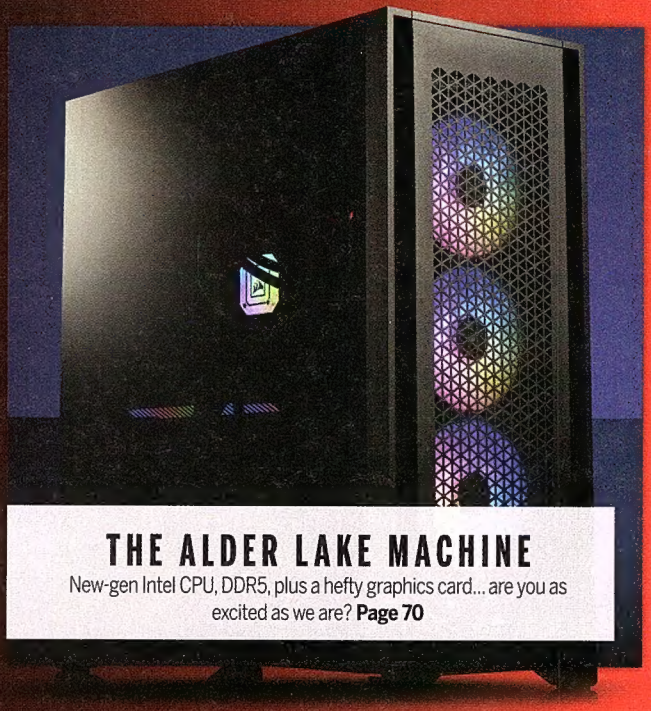

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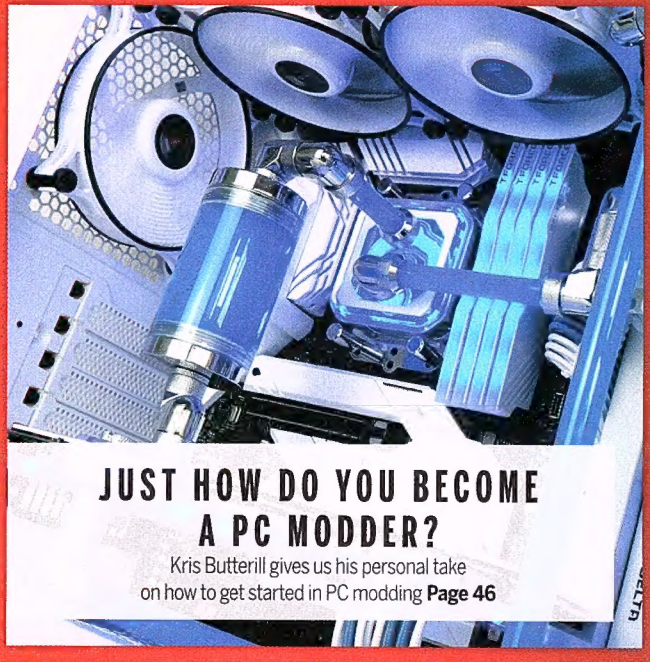
New-gen Intel CPU, DDR5, plus a hefty graphics card... are you as excited as we are? **Page 70**



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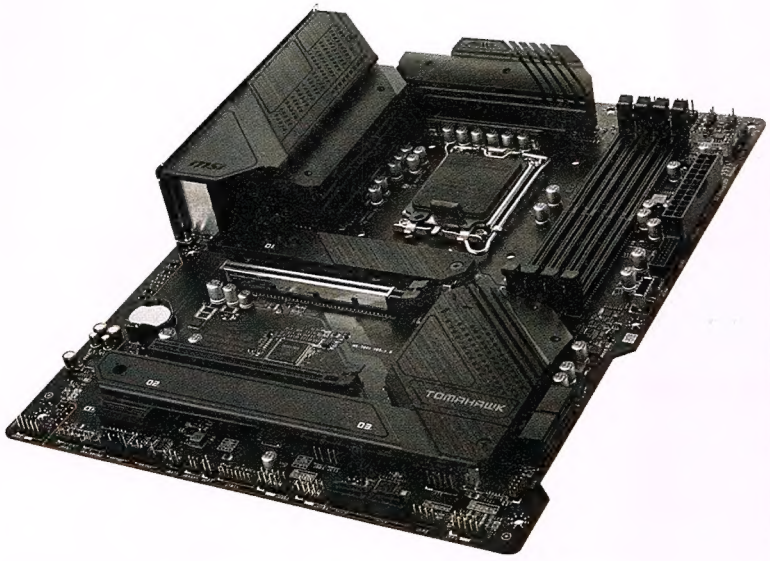
Kris Butterill gives us his personal take on how to get started in PC modding **Page 46**



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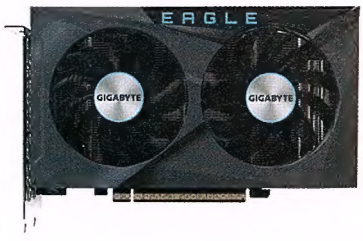

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Turn to page 22 now to find out how

"Championing technology doesn't mean we're unrelenting yes-men and -women, however, and APC aims to be as objective as possible in all our coverage."

HOW WE DO IT

Inside *APC*

Find out all about *APC*'s editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for forty years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, and beyond. We have two goals: to find the best modern tech and to help you make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

Independent reviews

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three attributes.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

Labs testing

APC strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance including storage read and write speeds, gaming and battery life.

In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter offers better ease-of-readability, but tables are more compact, so we use these in most cases where thoroughness is preferred. ■

APC TESTBED

The current *APC* testbed used in the Labs for benchmarking all components. This testbed is updated as new and relevant technology comes on stream.

CPU	AMD Ryzen 7 5800X
Motherboard	Asus ROG Crosshair VIII Dark Hero
GPU	Zotac RTX 3080 Ti AMP Extreme Holo
Memory	Crucial Ballistix Sport DDR4-3600 2x16GB
Primary SSD	Adata S70 2TB NVMe
Secondary SSD	Samsung 980 Pro 500GB NVMe
Cooling	Nzxt X73 360mm AIO
Case	Thermaltake Core P8
Power Supply	Corsair AX1000

APC AWARDS

APC EDITOR'S CHOICE
When a reviewed product scores 4.5 out of 5 or higher, it carries the Hot Award. These are products that exceed expectations and deliver a quality experience up there with the very best.

APC HIGHLY RECOMMENDED
You will see this award if a reviewed product has scored four out of five stars. It means most people can expect satisfying performance from the product, and that we would use it ourselves.

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intel CORE Supports 12th Gen Intel® Core™ Processors

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TECHNOTES

ALL THE NEED-TO-KNOW TECH NEWS

PIC: Shutterstock

META IS BUILDING THE WORLD'S FASTEST SUPERCOMPUTER

With 16,000 Nvidia A100 GPUs.

Meta (previously known as Facebook) is building a new AI supercomputer, called the AI Research SuperCluster, at a currently undisclosed location. According to Meta, it'll be the world's fastest supercomputer to date when complete, with a performance metric of over 220 Linpack petaflops. RSC is operational right now but is still being built out.

Specs for this new supercomputer are quite impressive, as the RSC currently features 760 of Nvidia's cutting-edge DGX A100 AI compute units and includes eight Nvidia A100 GPUs in each unit. This makes for a total of 6,080 GPUs for the entire supercomputer. But, once complete, RSC will pack a whopping 16,000 GPUs with an additional 1,240 DGX nodes to its name. The second installation phase will be completed sometime in July.

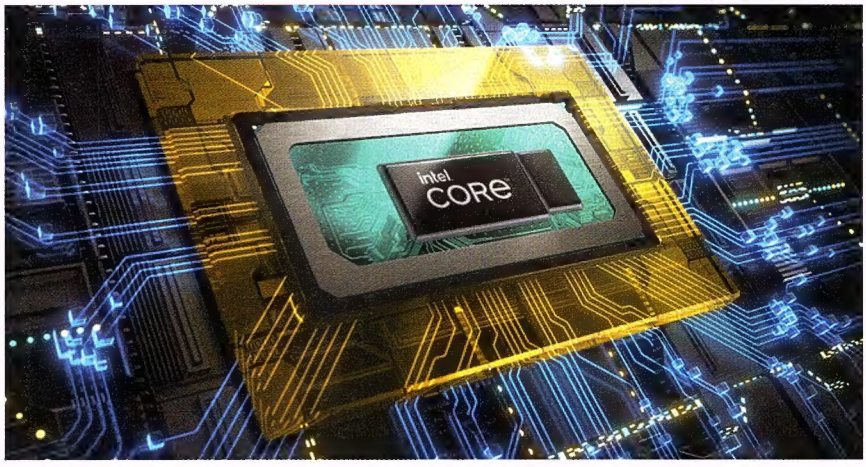
PIC: SpaceX

STARLINK INTRODUCES A PREMIUM TIER

Twice the speed for twice the price.

Elon Musk's Starlink service is rolling out a Premium Tier that can provide up to 500Mbps, twice the bandwidth that can currently be achieved with the standard service. The new tier will charge $3,500 for all of the required hardware, alongside a $700 deposit fee and an expected Australian price of around $500 for a monthly subscription service.

SpaceX is targeting businesses in remote regions that are currently being forced to pay significantly higher rates for poor service. Starlink is promising a better experience for business. Starlink Premium users can expect download speeds between 150Mbps and 500Mbps and latency as low as 20ms in most locations.



PIC: Intel

CHIP NEWS

Intel's flagship Alder Lake chip beats Apple's M1 Max

But there's a catch.

Intel's latest Core i9-12900HK processor may just have won the mobile x86 vs. Arm performance war, but it comes at a cost. The mobile 14-core Alder Lake chip has bested Apple's M1 Max in multiple workloads, including a 30 percent win in a multi-threaded test, but the former is far more power-hungry than the latter.

We've already seen what the M1 Max can do in the latest 16-inch MacBook Pro, and the Core i9-12900HK, which powers MSI's latest GE76 Raider gaming laptop, isn't a slacker, either. Both processors leverage different architectures, with the Arm-based M1 Max residing exclusively inside Apple's closed ecosystem, so an apples-to-apples comparison isn't always straightforward. However, some benchmarks do work on both types of hardware, including Geekbench 5, HandBrake, and Cinebench R23, so we charted out a few comparisons from the tests we ran in our lab.

In our Geekbench 5 testing, the Core i9-12900HK outperformed the M1 Max by three percent in the single-core test and six percent on the multi-core test, so it wasn't a landslide. The performance delta in the HandBrake test was more negligible, though, as the Alder Lake chip only bested the M1 Max by four seconds, representing a one percent margin in the video transcoding workload.

In Cinebench R23, the Core i9-12900HK delivered up to 30 percent more performance in the multi-core workload than the M1 Max.

Power consumption is just as important as pure performance, particularly when comparing mobile processors, and Apple's M1 Max is the undisputed champ in that area. While Apple doesn't advertise a TDP value for the M1 Max, the Core i9-12900HK has a 45W base power and 115W maximum turbo power rating.

For comparison, the MacBook Pro 2021 lasted 15 hours and 31 minutes in our battery test, whereas the MSI GE76 Raider survived for four hours and five minutes under the same environment. Admittedly, it's not the fairest comparison due to the hardware differences between the two devices, primarily in terms of battery capacity and the Alder Lake system's onboard GPU. Still, with the M1 Max exclusive to Apple's devices and the tech giant abandoning Intel chips, the comparison may be the best that we can do for now.

PIC: Apple

First International Trading Pty Ltd.

4G/LTE Dual-SIM Dual-Band Wireless VoIP VPN Router

CAT.6

5GHz 1733Mbps

2.4GHz 600Mbps

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MICROSOFT FENDS OFF 3.47TBPS DDOS ATTACK

DDoS attacks are getting bigger and bigger by the month.

Microsoft recently countered a record-breaking 3.47Tbps DDoS attack on its Azure servers in Asia according to a blog post by the company. That, it says, is the largest mitigated attack in history. According to Azure Networking product manager Alethea Toh, the attack occurred sometime in November, targeting an Azure customer in Asia. He believes this was the largest attack to ever be reported in history.

The attack originated from roughly 10,000 sources across the world, using a combination of multiple attack methods for UDP reflection on port 80 including, SSDP, CLDAP, DNS, and NTP. The attack lasted around 15 minutes. In December Microsoft also had to deal with another attack that was nearly as large at 3.25Tbps, but lasted far longer.

PIC: leodanmarjod

WORKING PROTOTYPE OF INTEL'S FAILED LARRABEE GPU SELLS FOR OVER $7,000

History under the hammer.

Collectors of rare PC hardware have just missed out on the chance to own a little piece of history: a prototype Intel GPU claiming to be the only working Larabee board in the world. It sold on eBay France for a mere €4,650 (AU$7,375).

Larrabee was Intel's 2008-vintage attempt to make a GPU, or rather a GPGPU, separately from the project that led to Iris Pro. Rather than following in the footsteps of Nvidia and ATi, Larrabee used the X86 instruction set with special extensions, and the GPU functioned more like a hybrid of a CPU and GPU.

The Larrabee technology passed to Intel's supercomputing division, which eventually built an accelerator card for high-performance computing released as Knights Corner, and the Xeon Phi co-processors, in 2012.

HARDWARE NEWS

PC gaming hardware exploded to $8.05 billion in 2021

One of the most profitable markets in the world.

According to a report by the NPD Group, the PC gaming hardware and accessories market skyrocketed during 2021, in no small part due to the pandemic. This has allowed the PC hardware and accessories industry to reach a stellar $8.05 billion dollars in value for the whole year.

Most of the revenue was generated by desktop computers, laptops, and PC microphones, increasing by 38, 29, and 25 percent, respectively, during 2021. Pure sales volume growth was driven by PC microphones, monitors, and laptops by up to 27, 17, and 16 percent, respectively.

PC gaming also saw significant gains in 2021, with digital PC content bumping up an additional five percent in revenue last year for a total of $11.07 billion. This was also assisted by increased average playtime of PC gamers, which was recorded at 7.7 hours per week, a 1-hour increase over 2020.

However, due to both 2020 and 2021's rapid growth in the PC market space, NPD predicts 2022 will be the first year we'll see a decline in sales and revenue (by around four percent).

PC gaming also saw significant gains in 2021, with digital PC content bumping up an additional 5 percent in revenue last year for a total of $11.07 billion.

PIC: Intel

INTEL ANNOUNCES OHIO FAB COMPLEX

Two new fabs For $28B, and space for more.

With fab expansions on tap across the entire semiconductor industry, Intel is laying out its own plans for significantly increasing their production capacity by announcing their intention to build a new $28 billion fab complex in Ohio. With the paperwork already inked and construction set to begin in late 2022, Intel will be building two new leading-edge fabs in their new Ohio location to support future chip needs.

Intel's announcement follows ongoing concerns about chip fab capacity and national security, as like other chip fabs, Intel is looking to expand their capacity in future years amidst the current chip crunch. All the while, the United States government has become increasingly mindful about how much chip production takes place in geopolitically tricky Taiwan, placing additional pressure on firms to build additional fabs within the US.

It's time to discover the best of the best in tech

The 2022 Australian PC Awards is coming!

www.australianpcawards.com.au

In March, *APC*, *TechLife*, *TechRadar*, *PC PowerPlay* and *PC Gamer* will announce the best of the best for every important PC category, as judged by our team of experts. Grab a copy of *APC* or *TechLife* in March to see all the finalists, highly commended and winners!

THIS YEAR'S CATEGORIES:

Best Motherboard Maker
Best Value Motherboard
Best Premium Motherboard
Best GPU Maker
Best Value GPU
Best Premium GPU
Best Value CPU
Best Premium CPU
Best Internal Storage Maker
Best External Storage Maker
Best SOHO or Home NAS
Best Value Laptop or 2-in-1
Best Premium Laptop or 2-in-1
Best Gaming Laptop
Best Desktop PC Maker
Best Memory Maker
Best Cooling Product
Best Monitor
Best Keyboard
Best Mouse
Best Gaming Headset
Best PC Case
Best Router
Best Reseller

PLUS Gold Award for Best Company

apc TECHlife techradar PC PowerPlay PC GAMER

TECH BRIEF

Intel to unveil Bitcoin-mining 'Bonanza Mine' chip

May lower demand for mining on new Xe GPUs.

It appears that Intel could enter the Bitcoin-mining hardware business, but not with its new upcoming GPUs. The ISSCC conference is a yearly gathering of the best and brightest minds in the chip industry. This year, Intel has a presentation scheduled in the 'Highlighted Chip Releases' category to outline a new "Bonanza Mine" processor, a chip described as an "ultra-low-voltage energy-efficient Bitcoin mining ASIC." That means Intel could soon compete with the likes of Bitmain in the market for specialised ASICs for Bitcoin mining. Intel also commented on the new chip, saying "Intel has done design work around SHA 256 optimised ASICs for several years beginning with pathfinding work done in Intel Labs. We will share more details in the future."

The presentation comes on the heels of comments from Intel's GPU Chief Raja Koduri during a live stream last December, indicating that the company is working on specialised hardware for blockchain/cryptocurrency technologies.

Bitcoin is typically mined on ASICs, which are specialised processors specifically designed to execute one type of workload. ASICs afford efficiency and performance advantages over more complex types of chips, like CPUs and GPUs, that can perform the same task. As a result, the overwhelming majority of Bitcoin mining occurs on ASICs, with companies like Bitmain providing the specialised silicon to miners at hefty premiums.

The first signs of Intel's interest in mining hardware surfaced in 2018 in the form of a patent for a specialised processing system that uses an optimised SHA-256 datapath (a cryptographic algorithm) for high-performance Bitcoin mining. As with all patents, the end product takes some time to come to market, but Intel has a wealth of experience in hardware-assisted SHA-256 algorithms due to the use of these instructions in its CPU products. Paired with its silicon production capabilities, Intel could be a particularly competitive entrant into the Bitcoin hardware market, especially given the focus on low-power, high-efficiency operation.

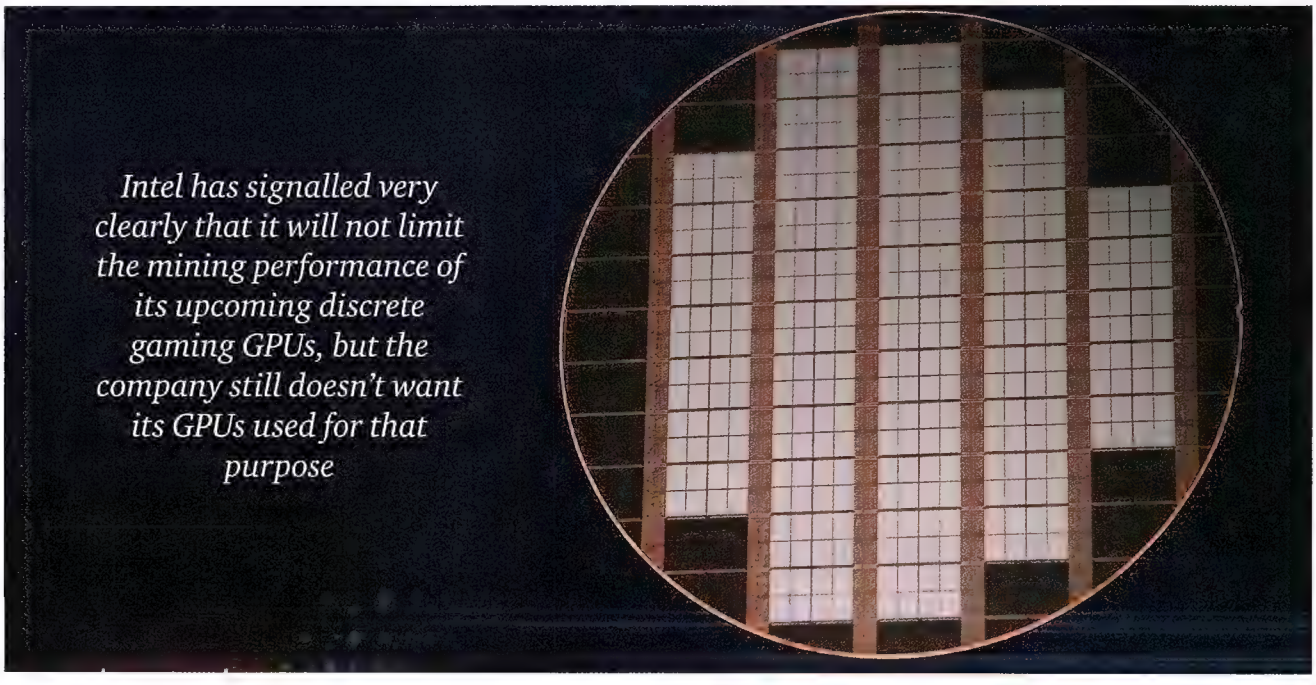
Fast forward to December 29, 2021, and Intel's Systems and Graphics Architect, Senior Vice President and GM Raja Koduri appeared on popular streamer Dr. Lupo's show to promote the company's launch of its first gaming GPUs, the Arc Alchemist lineup that will launch this year.

Intel has signalled very clearly that it will not limit the mining performance of its upcoming discrete gaming GPUs, but the company still doesn't want its GPUs used for that purpose. Naturally, GPUs are used for Ethereum mining and other types of coins – not Bitcoin – but the topic led Koduri to make a few interesting statements about blockchain technology, which is the fundamental underlying tech behind crypto.

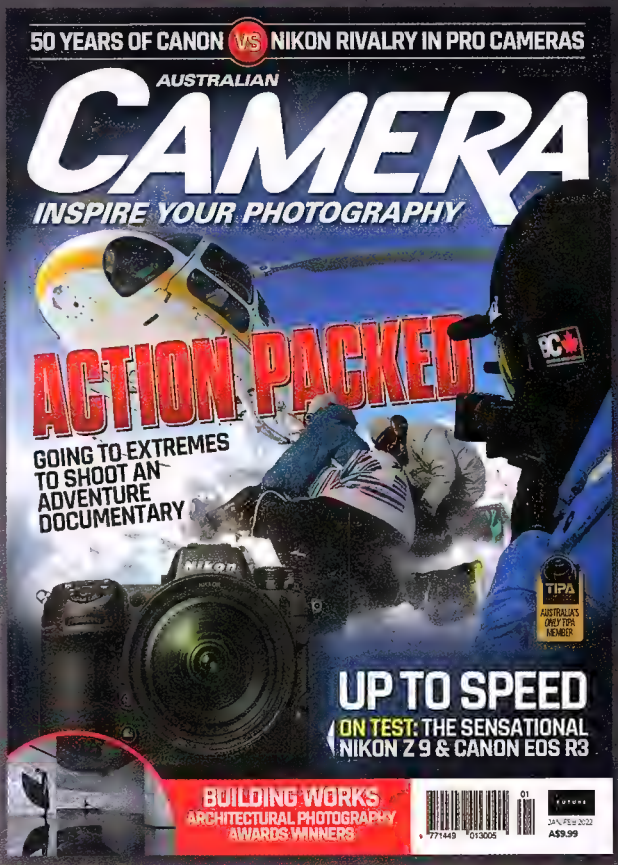
Koduri explained that Intel doesn't have an install base as a newcomer to the discrete gaming GPU market. As such, Intel would rather its GPUs be used by gamers than miners. Given the timing of the ISSCC presentation, and the subject matter, it appears that Intel will share that information about the new hardware on February 23rd. The 'DS1' moniker in the presentation listing denotes that Intel will have a video demo of the chip.

Paul Alcorn ■

Intel has signalled very clearly that it will not limit the mining performance of its upcoming discrete gaming GPUs, but the company still doesn't want its GPUs used for that purpose



THE FUTURE OF MAGAZINES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OPINION

APC'S EXPERTS COVER THE HOT TOPICS

END USER

The games industry is consolidating, and that's not good news for metaverse-averse gamers

Microsoft's Activision-Blizzard acquisition makes it the team most likely to win a metaverse arms race, writes Shaun Prescott.

When Microsoft announced its intention to acquire Activision-Blizzard in January, it felt like a historical moment. It *was* a historical moment. Indeed, for those of us who doubted the company could make a more disruptive move than its 2020 acquisition of Bethesda, it was evidence that the whole context of the business is rapidly changing. With the biggest tech companies setting their sights on huge-yet-ambiguous concepts like the so-called metaverse, it'll really be a matter of whoever has the most cash and best tech to drive that stake in further. One thing is for sure: gaming is no longer about doling out a new military shooter every September. That innocent past is long behind us.

Now, gaming – at least to the biggest corps – is about building an audience and keeping it. Microsoft stopped talking about console unit sales long ago; now it talks about player engagement. Sure, that move coincided with the Xbox One generation, when hardware unit sales were dramatically behind Sony's, but as time has passed it's started to make a whole lot more sense, partially in light of Xbox Game Pass's ongoing success, but especially because engagement is the metric that drives virtually every social-oriented tech company.

The thing about the metaverse, is that, actually, it kinda already exists. This isn't just a pundit's gut feeling: Spencer has said as much himself. Sure, *Second-Life* is often used as an example of a proto-metaverse, because of its uncanny similarity to Mark Zuckerberg's typically insipid imagining... but *World of Warcraft* is basically a metaverse. *Fortnite* is a metaverse, and Epic Games' CEO wants to make it even more metaverse-y (whatever that entails). Lucky for Microsoft, it's soon to own *World of Warcraft*, just as it owns *Minecraft*, and soon *Hearthstone*, and soon *Call of Duty*... the list goes on. When you look at it this way, gaming companies have a much better position from which to launch a metaverse that actually stands a chance to attract the kind of engagement a metaverse would surely need. Microsoft and Epic Games are far better positioned than Meta.

And Microsoft even moreso, with its acquisition of some of the most beloved media franchises in the world, that also happen to have strong metaverse foundations built into them already. It's already got a smorgasbord of worlds to choose from that audiences already want to be a part of, whereas on the flipside, who wants a virtually inhabitable Facebook? Probably only your racist distant relatives.

SHAUN PRESCOTT
Author, *PC Gamer* editor and passionate technology observer, Shaun covers trending tech topics for *APC*.

Sure, Microsoft's move towards games industry consolidation is a canny one for them, in terms of the amount of money they stand to make. But it's a company with an absolutely formidable scale, with properties that make them an almost dead certainty for metaverse dominance – if it so happens to want to move into that space. Which, well, it's already there.

But all questions of metaverse aside, games industry consolidation perhaps doesn't bode well for audiences. Putting aside the matter of potential platform exclusivity (ie: future *Call of Duty* or *Elder Scrolls* games not being available on Sony devices), the future of blockbuster games, all developed by studios reporting into the same behemoth company, will almost certainly lead to homogenisation. One could argue the blockbuster landscape has always been so, but now that engagement and player retention is seemingly more important than huge launch sales – expect games to be structured around these principles. ■

Can more innovation help solve the global chip shortage?

While the US and UK commit to $52bn investments in chip fabrication facilities, a 22-year-old electrical engineer builds processors in his parents' garage.

JOEL BURGESS
When not reviewing PCs for *APC* and writing our funny pages, Joel likes to ponder tech and how it's used.

The uptick in automobile processors and demand for consumer tech over the last few years has made it pretty obvious that the existing global semiconductor manufacturing supply chain was far too centralised to meet the demands of an increasingly technological world. U.S. president Joe Biden vowed to create a more amicable environment for semiconductor plant investment on US shores in 2021, and Intel seems to be cashing in on this already, announcing in January two new Ohio 'mega fabs' that it aims to have up and running by 2025.

Combine this with the recent lessons around the importance of guaranteed supply, gleaned from various Covid medical supply shortages or the ever intensifying trade war between the West and China, and it's perhaps unsurprising that the European Union announced it's planning to encourage its own processor manufacturing facilities too.

In late January, the EU Commissioner for Internal Markets, Thierry Breton, announced it would release details of a proposed Chips Act, that would see funding "commensurate" with the $52Bn U.S. commitment for encouraging local 'mega fab' investment. The funding comes with strings that would require guarantees for European markets during shortages, taking inspiration from the Defence Production Act in the U.S. The allocated Chips Act funding is predicted to be painful for some EU countries that were depending on large economic relief packages to recover from the pandemic, but the region has already set a target to supply 20 percent of the world's processors by 2030, which will require a large commitment over the remainder of the decade.

While commercial processor fabrication has an extraordinarily steep learning curve, requiring US$10-20Bn in upfront investment and takes a minimum of three years to be up and running, one 22 year old New Jersey YouTuber has set up his own DIY chip plant in his parent's garage. In August 2021, Sam Zeloof manufactured his own 1,200 transistor processor using salvaged and home made equipment. Sure, this is 50 years of technical advancement behind the 57 billion transistors you'll find on the 5nm TSMC built Apple M1 Max processor, but it's a pretty fascinating way to learn more about chip fabrication for anyone interested in what makes computers tick. You can read about it at **tinyurl.com/APC504CPU**.

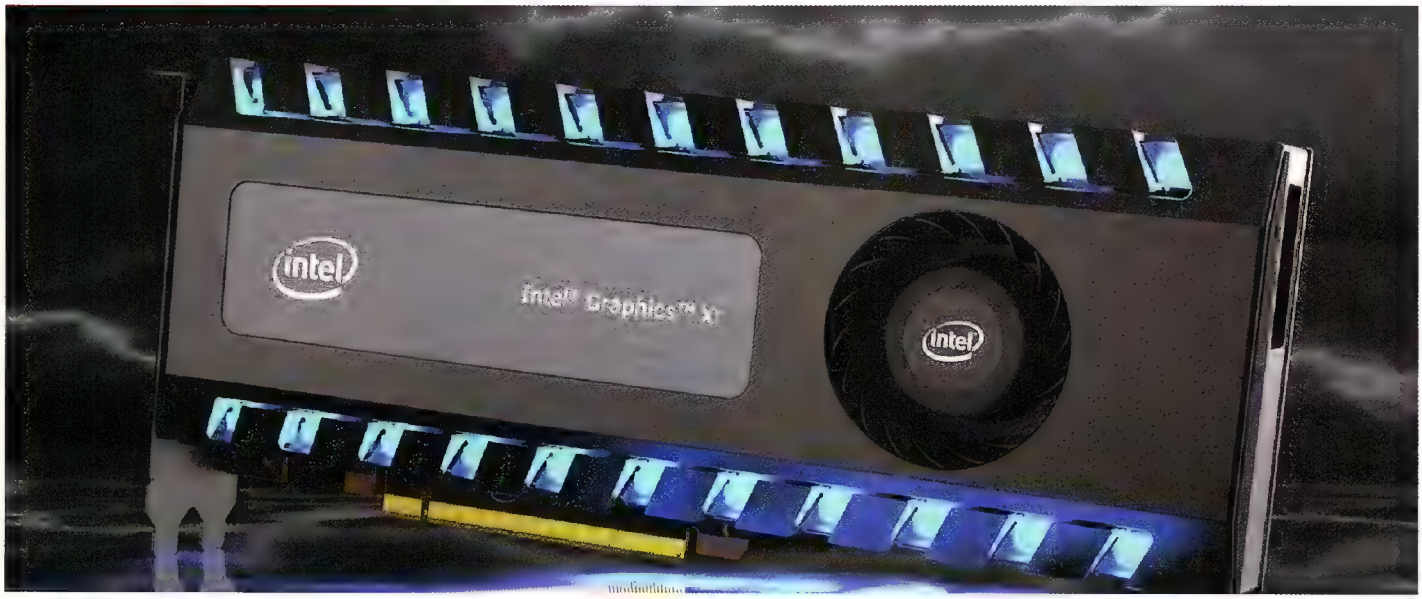
Zeloof said that when he initially began blogging about his ambition to make processors at home, some industry experts reached out to him to warn him that it would be impossible. And making chips at today's level probably would be, but Zeloof was able to tap into techniques used by early 1970s engineers to make processors using more accessible machinery. Fortunately there's an abundance of old chip manufacturing gear from Californian companies circulating online, so Zeloof was able to find bargains like a US$250,000 1990s electron microscope going for $1,000 that he now uses to check the processors he makes for defects.

The process has also required genuine innovation. In order to get around forking out for a US$150 million photolithography machine, Zeloof attached a conference projector to a microscope to burn transistor templates into silicone that was coated in a photosensitive layer.

While he doesn't know what he wants to do when he finishes his electrical engineering degree from Carnegie Mellon this year, we're hoping he continues to remind engineering innovators that small scale processor fabrication might be more achievable than you'd think. ■

In August 2021, Sam Zeloof manufactured his own 1,200 transistor processor using salvaged and home made equipment.

22-year-old Sam Zeloof makes his own CPUs at home using cast-off second hand equipment. How hard can it be?



TWO BITS

The graphics card market needs a reset

And Intel is shaping up as the company to do it.

In this issue (page 34) we review the AMD RX 6500 XT. At $400 or more, it's a symptom of how damaged the gaming GPU market is. It's an entry level card at a ridiculous price. But there's another manufacturer putting the finishing touches on its own gaming cards. Intel. Its upcoming Arc series of GPUs may end up restoring the GPU market. The first Arc products could appear as soon as March.

Intel's Arc GPUs aren't expected to be 3090 Ti slayers. Rumours indicate that the top tier Arc card could end up around RTX 3070 Ti levels of performance. That's not stunning relative to Nvidia and AMDs flagships, but if priced right, and available in volume, Arc cards could end up in a lot of gaming machines, particularly those who have been starved of affordable GPUs since the start of the pandemic. In fact, Intel may decide to be aggressive in its pricing in order to gain market share. I certainly hope so!

Despite having its own fabs, Intel is actually going to contract TSMC to produce first generation Arc cards, which might mean that initial supplies will be limited. I hope not, but it all depends on how generous Intel was when negotiating with TSMC. Intel has an aggressive process roadmap Intel can be expected to shift Arc production in house eventually.

CHRIS SZEWCZYK
A life-long PC tech enthusiast, Chris has worked acoss the industry in many areas as a product and technology expert.

Intel has a lot of GPU experience. Its graphics are found in millions of Intel CPUs and its Xe architecture is set to be the base for several generations of Arc GPUs. Obviously, it found that scaling the Xe architecture from basic integrated graphics to high powered discrete solutions wasn't as difficult as building an architecture from scratch.

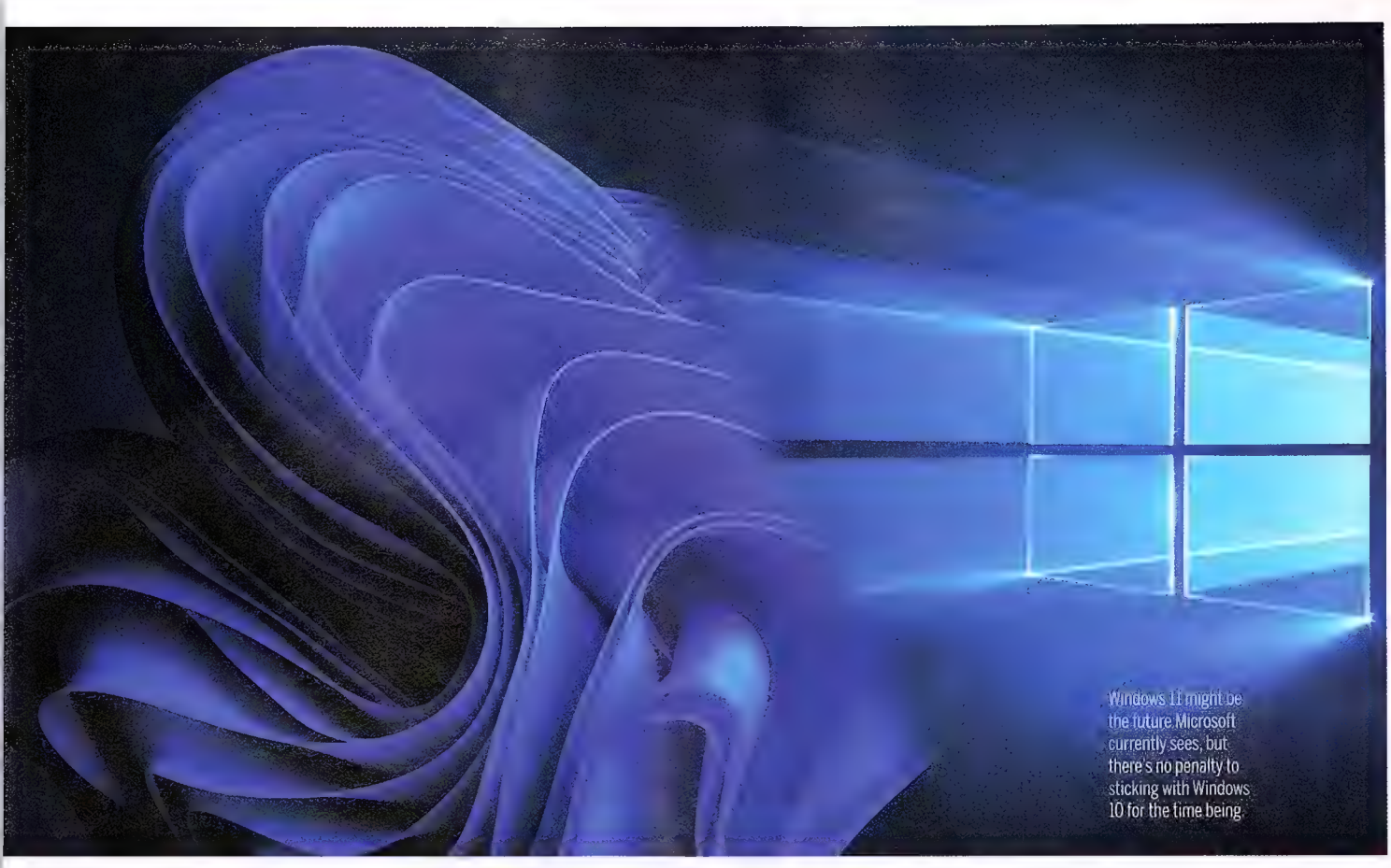
Intel's motives aren't entirely consumer-oriented and altruistic. It's always got an eye on the lucrative high performance and enterprise computing market. Nvidia and AMD are both making major strides in this area. Simulation, AI, and supercomputing applications among others are increasingly reliant on GPU compute products. Nvidia's A100 and AMDs Mi200 series will be joined by Intel's Ponte Vecchio HPC GPU. There are billions of dollars to be made.

In the mid to long term we have to remember that Intel, along with TSMC and Samsung, is spending many billions of dollars to expand its manufacturing capacity. Though there's a long lead time involved, investments made since the start of the pandemic should start bearing fruit sooner rather than later. Could we see a GPU oversupply in 2023 onwards? Wouldn't that be a development?

In addition to improvements on the supply side, another hope is that GPU mining demand will come to an end in the second half of 2022 as Ethereum ever so slowly transitions towards its proof of stake consensus mechanism. In advance of this, demand should drop off as miners have less time to make back the cost of expensive GPU outlays.

In conclusion, basic economic theory suggests that more product from Intel in tandem with less (if not effectively zero) mining demand means lower prices and more stock on shelves. PC gaming is struggling now, and it's hard to see how it can do anything but shrink when entry level GPUs start at $500. Intel's Arc graphics cards can't come soon enough. ■

Intel's motives aren't entirely consumer-oriented and altruistic. It's always got an eye on the lucrative high performance and enterprise computing market.



Windows 11 might be the future Microsoft currently sees, but there's no penalty to sticking with Windows 10 for the time being.

TECH TALK

Windows 10 vs. Windows 11

Jarred isn't much liking the cons vs pros considerations...

Oh, Windows 11, how I love to hate you. Change for the sake of change doesn't sit well with me, and Windows 11 has completely altered the comfortable Windows 10 house I've been living in since 2015. A new coat of paint would have been fine, but it seems as though the UI designers also felt the need to rearrange the furniture, switch around the drawers, and clean house a bunch of functionality that I liked. This is not okay.

Context menus now require an extra click to get at the menu I actually wanted, but what's worse is the way some functionality is simply gone. I may be the exception, but I want all my system tray icons to always be visible. I've encountered far too many PCs where more than a dozen 'utilities' are running in the background sucking down system resources. Even worse, some malware sits in the system tray, and hiding icons by default is a terrible idea. On Windows 10 and earlier, there's a simple toggle to show all icons, but Windows 11 killed it.

The good news is that the performance hasn't changed between Windows 10 and Windows 11. In fact, for newer PCs running Intel's Alder Lake CPUs, you'll pretty much be forced into running Windows 11 whether you want to or not. The hybrid CPU architecture requires a new scheduling algorithm and, for the time being, Microsoft doesn't want to port that back to Windows 10. It's like when AMD and Intel dropped support for Windows 7/8 for Ryzen and 7th Gen processors. If you want a new Alder Lake system, it can use Windows 10, but won't run optimally.

But what about for people not running the latest and greatest CPUs? Is Windows 11 any better – or worse – than Windows 10? I set about running a bunch of benchmarks on a Core i9-9900K system using an AMD Radeon RX 6900 XT and an Nvidia GeForce RTX 3080 Ti. Both systems had a clean install and all the other hardware remained unchanged, except one has Windows 10 and the other has Windows 11. The results are mind-numbingly boring.

Across a 15-game test suite, the overall performance difference between Windows 10 and Windows 11 at three different resolutions was less than one percent. There were a few differences of up to three percent, but that's basically within the margin of error. Sometimes Windows 10 was a bit faster, sometimes Windows 11 came out ahead. But in practice, there was no significant change. That's great because I'd hate to see the new OS penalise or benefit performance. Maybe I'll adapt over time to the Windows 11 changes, and I do plan on upgrading to an Alder Lake system eventually, so I will basically be forced to make the change during that upgrade. But my old PCs will continue to run Windows 10, even if Windows 11 is a free upgrade, and I can't even begin to imagine trying to get most of my family members and friends to make the switch. ■

The good news is that the performance hasn't changed between Windows 10 and Windows 11. In fact, for newer PCs running Intel's Alder Lake CPUs, you'll pretty much be forced into running Windows 11 whether you want to or not.

JARRED WALTON
Jarred Walton has been a PC and gaming enthusiast for over 30 years.

Fairphone True Wireless Stereo Earbuds

Better than the last one.

Welcome, Fairphone, to the world of wireless earbuds. Fairphone smartphones consistently rank tippy-top for repairability, so will its True Wireless Stereo Earbuds manage the same trick?

Major tech specs

- In-ear detection and touch control
- Active noise cancellation with transparency mode
- Bluetooth 5.3, A2DP, HFP, AVRCP (Airoha AB 1562 Bluetooth audio SoC)
- 10 mm / 32 Ohm drivers
- IPX4 splash resistance
- 10×9.8×5.6 mm, 0.1 Wh battery

Key findings

We kick off disassembly with the most removable, and cleanable, bit: the flexible tips – much like you find on competing models, including AirPods Pro. With three different size options, you've got a good chance of finding a set that fits properly.

Next, hoping to keep it nondestructive, we aim for a likely seam and get slicing with an opening wheel – no heat required. The plate we peel up has the touch controls mounted to it, but your taps are communicated via spring contacts, so no booby trap cables in sight! Inside, we can already spot the glued-in motherboard. Forcing it out seems unwise, so we'll backtrack a bit and try what has become our standard opening procedure for the generally not-so-repairable earbud category.

Putting the squeeze on the speaker portion of these buds, with help from our trusty bench vice, deforms the buds' outer shell just enough to open up a chink in the armour – a seam. Pressure and heat make diamonds, and also progress on our teardown. After some picking and prying, we see a tiny battery pouch deep inside – but it's mostly cables and solder in there.

We opt for battery removal, because it gives more room to maneuver, and because this cell will someday need replacing anyway. Fairphone says they're engineered to last "twice as long" as the competition, but that's not saying much. On our way to the driver (which is glued down in a super-tight recess), we see the ribbon cable held captive by brackets, which in turn are secured by plastic rivets. With heavy hearts, we break out the flush cutter – it's about to get destructive in here.

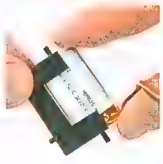
Since at first we're not succeeding, we pry, pry again with some heat and a deft spudger. The buds finally give up their (decidedly non-modular) internals: motherboard, driver, and battery. On this side of the motherboard, we find an indicator LED and spring contacts for touch controls and for charging the buds.

The earbuds were a disappointment, so hopefully, the charging case will prove more cooperative. A spudger is all we need to move the insides outside – no glue and no screws. We feel the optimism building, but alas, separating the bits reveals a whole bunch of soldered cables.

There's no adhesive for its protective sleeve, but the battery is certainly securely soldered. The rest of the cables are similarly soldered, we also spot a simple hall effect sensor up top to track the lid state (open/closed).

Repairability Score: 1 out of 10 (10 is easiest to repair).

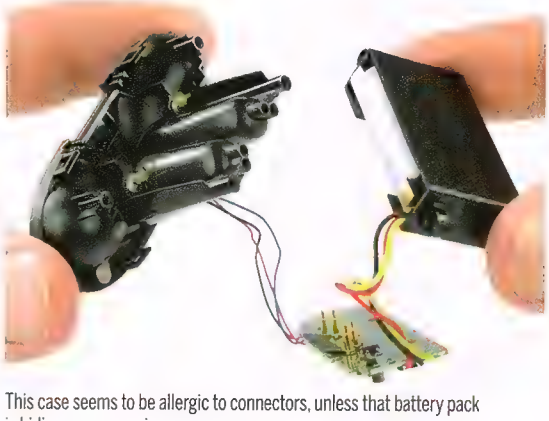
We may have had inflated hopes for Fairphone's first earbud offerings, but we're still disappointed they aren't easier to service. While the earbuds can be opened with gentle prying, nothing inside is easily repairable. The charging case and earbud components, including batteries and port, are soldered together. Fairphone does things right with its earbuds' materials (Fairtrade Gold and recycled plastics) and we're all for that. It just won't lengthen device life as repair does. ■



The case battery provides 1.85Wh (500mAh @ 3.7V), which should re-juice those twin 0.1Wh earbud batteries a handful of times.

The plate we peel up has the touch controls mounted to it, but your taps are communicated via spring contacts, so there are no booby trap cables in sight.

While we're no fans of glue, we're even less fond of destructive fasteners. At least glue can be reapplied.

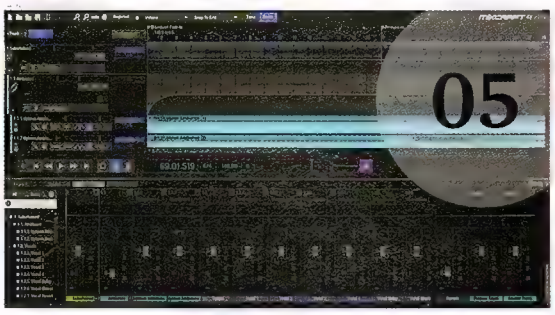


This case seems to be allergic to connectors, unless that battery pack is hiding some surprise.

THE LIST

The top five audio production programs

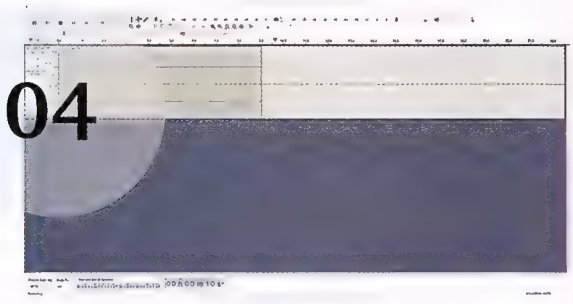
Music production no longer involves just a guitar and a microphone. These days it is often carried out on a PC with the aid of a digital audio workstation (DAW). This allows the user to mix, tune, stitch and compile recordings together to produce a final, polished piece of music, whether that's music, sound effects, or game sounds. Like all programs, there are many variants of DAWs available, each with their own pros and cons. Here, we list our top five favourites.



ACOUSTICA MIXCRAFT 9

Mixcraft 9 Recording Studio US$99, Mixcraft 9 Pro Studio US $199 | www.acoustica.com

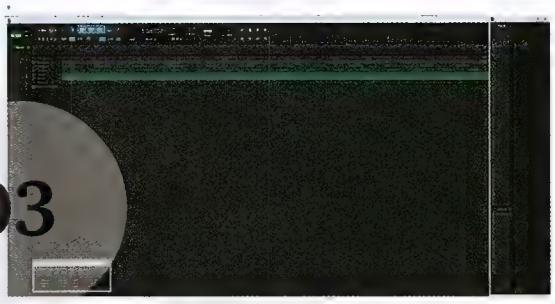
Apple fans rave about how easy Garage Band is to use – it's a fun application that can be used in both a casual and professional way. But what about Windows users? That's where Acoustica Mixcraft 9 comes in. It's ideal for beginners, yet it's not a basic program. Configured in a more traditional approach, it has a huge plug-in library, a great mixer, and a methodical workflow.



AUDACITY

$Free | www.audacityteam.org

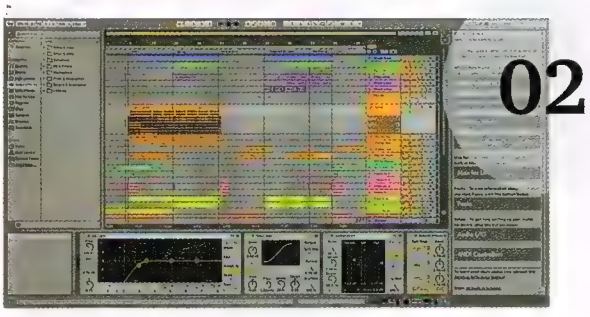
We had to throw this free, open-source application into the mix when it came to top DAWs. Yes, it looks pretty outdated and we wouldn't necessarily recommend it for professional or commercial use, but the best thing about it is that it's available to download for free. It's also pretty easy to get to grips with and if you want something to play around with, mix recordings together, splice them up or change formats, then Audacity is worth installing on your PC.



PRO TOOLS

Pro Tools US$399pa, Pro Tools Ultimate US$800pa
www.avid.com

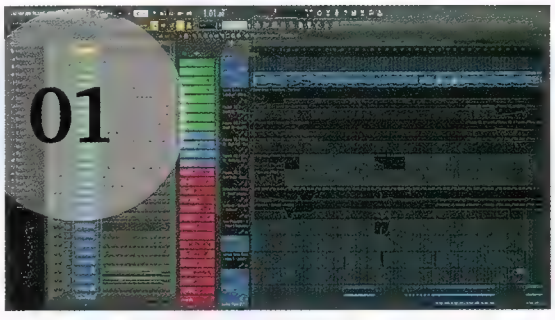
For recording engineers, mixers, musicians, and producers, Avid Technology's Pro Tools is one of the best DAWs. With its mastering capabilities second to none, it is ideal for large studio environments.



ABLETON LIVE

Live 11 Intro $149, Live 11 Standard $659, Live 11 Suite $1,099 | www.ableton.com

With a quick and efficient workspace and a full suite of features, Ableton Live is a great program for producers. Launched in 2001, this DAW is not just a recording program, but an instrument in its own right.



FL STUDIO

Signature Bundle $449, All Plugins Edition $664
www.image-line.com

FL Studio has been around for 20 years, and many top producers and DJs started here. Still one of the best, it looks fantastic and has lots of presets and effects. FL Studio Fruity Edition $139, Producer Edition $289,

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SWEET SPOT CPU: INTEL i5-12400

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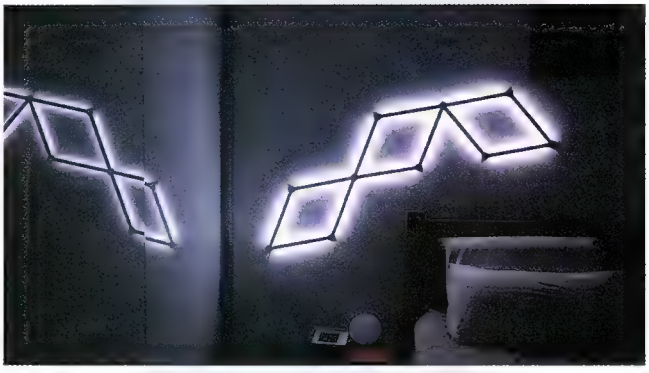
CHAPTER II · 1 OF 19
It was pleasant to wake up in Florence, to open the eyes upon a bright bare room, with a floor of red tiles which look clean though they are not; with a painted ceiling whereon pink griffins and blue amorini sport in a forest of yellow violins and bassoons. It was pleasant, too, to fling wide the windows, pinching the fingers in unfamiliar fastenings, to lean out into sunshine with beautiful hills and trees and marble churches opposite, and close below, the Arno, gurgling against the embankment of the road.
Over the river men were at work with spades and sieves on the sandy foreshore, and on the river was a boat, also diligently employed for some mysterious end. An electric tram came rushing underneath the window. No one was inside it, except one tourist; but its platforms were overflowing with Italians, who preferred to stand. Children tried to hang on behind, and the conductor, with no malice, spat in their faces to make them let go. Then soldiers appeared – good-looking, undersized men – wearing each a knapsack covered with mangy fur, and a great-coat which had been cut for some larger soldier. Beside them walked officers, looking foolish and fierce, and before them went little boys, turning somersaults in
A ROOM WITH A VIEW · 20 OF 257
kobo

$279.99 | au.kobobooks.com

Kobo Libra 2

Read into the value.

Kobo already has some excellent ereaders in its hardware catalogue, but in the Libra 2, the Japanese-Canadian company has a trailblazer. Its launch price is just $10 more than the Libra H2O it's replacing but the value for money here is excellent. There's 32GB of internal storage for starters (a first for a Kobo ereader), Bluetooth support for audiobooks (another first for Kobo), a USB-C charging port (yet another Kobo first) and a bigger battery. Its screen is the latest E Ink Carta display, and hence more responsive, and it retains the winning asymmetric design for single-hand use, with OverDrive, Pocket and Dropbox support. Need we say more?



$349.99 | nanoleaf.me/en-AU

NANOLEAF LINES

Line it up and light it up

Smart lights seem to come in every shape and form these days, but the Nanoleaf Lines are striking in their simplicity – they're just backlit light bars with all the colour and fun you see in most modular smart lights. While most panels look drab when switched off, the Lines can be accessorised to look like (line) art. And when switched on, they're mesmerising – you can stick 'em on a wall or mount them on the ceiling! Heck, they'll even double up as a Thread border router to control other Thread-enabled smart devices. If this lights up your eyes, then just wait for a major sale and you'll see it discounted.

TBC | www.samsung.com/au

SAMSUNG THE FREESTYLE

A super-stylish projector that does more

Portable projector, 360° speaker and ambient light source – that's Samsung's new The Freestyle. It can be plugged into the mains or taken on an adventure on account of its accepting batteries. Weighing just 830g, it's versatile cradle rotates a full 180°, so you can watch videos on tables, floors, walls or ceilings with projections between 30 inches and 100 inches in size. It's one party trick that no other projector can do – it plugs into a standard E26 (screw in) light bulb socket for some mood lighting. Heck, it even offers some Samsung smart TV features with built-in streaming services, screen mirroring and casting compatible with Android and iOS.

$13,500 | hleica-store.com.au

Leica M11

A legend gets reinvented

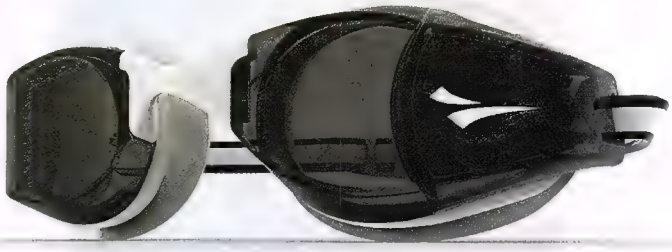
Combining the experience of old-school rangefinder photography with modern camera technology is the new Leica M11. Its headline features are its triple-resolution sensor capable of producing up to 60MP stills (imagine the level of detail on those!) and a new processor that can handle 14-bit colour with up to 15 stops of dynamic range. That's not all – it's the first M-series camera to offer an electronic shutter and the first to come with internal storage (64GB – unheard of in modern cameras). Like most Leica shooters, the M11 is still a niche snapper. Much like a Porsche 911 it lives in a world of its own, affordable only by those looking to buy into the lifestyle.

$1,049 | garmin.com

GARMIN FENIX 7

Put a little shine on your wrist.

Garmin's new Fenix 7 is the king of multisport watches, that does it all and better than other watches. A flawless piece of design, the Garmin Fenix 7 is a beast of a smartwatch and improves on the already excellent Fenix 6, which is a great achievement. Just like previous Fenix models, the Fenix 7 is big, bold and works well as an outdoor, running and triathlon watch; but very few people will be able to make the most of the thousand features it has. Our favourite feature? It's the flashlight. An actual working flashlight. A total game changer!



$265 | finisaustralia.com

FINIS SMART GOGGLES

Smart tech for your underwater face.

The Finis Smart Goggles can be connected to a small module that fits into the corner of one lens, and tracks swimming metrics like laps, stroke type, splits and rests. It also packs in a digital display that you can use to keep a close eye on performance and receive feedback during your swim. While they work reliably on the tracking side of things, the display isn't the easiest to see. They offer rich stats in its companion app, but the cheaper, more feature-packed Form smart swimming goggles will give you a better all-round experience.

REVIEWS

THE HOTTEST GEAR LABS TESTED

$3,099 | rog.asus.com

Asus ROG Zephyrus G14 Alan Walker Special Edition

Gaming meets music in Asus's latest portable PC.

Specifications
CPU: AMD Ryzen 9 5900HS; Graphics: RTX 3050 Ti; RAM: 16GB DDR4; Screen 14-inch, IPS, 2,560x1,440, 120Hz; Storage: 1TB Samsung M.2 SSD; Ports: HDMI, 2x USB-C, 2x USB-A; Connectivity: Wi-Fi 6 (802.11ax)+Bluetooth 5.1; Camera: None; Weight: 1.7Kg.

Give it up for the new Asus ROG Zephyrus G14 Alan Walker Special Edition. It's a new version of the second iteration of what was already a great laptop.

The original Asus ROG Zephyrus G14 was something of a genre buster when it arrived last year with its compact 14-inch proportions, awesome AMD CPU, and great gaming performance.

This second-generation Special Edition model carries over that basic proposition but adds an unusual twist, namely collaboration with the DJ and musician Alan Walker. As we write, Walker currently has the 19th most popular video on Youtube with no fewer than 3.2 billion views, not to mention over 10 billion channel views. Not bad. Anyway, Walker has collaborated with Asus to produce a version of the G14 that fuses music with gaming. The basic design of the G14 is carried over, complete with the funky Anime Matrix programmable LED feature on the rear. But various tweaks, including a change to metallic grey, fabric inserts, and new keyboard colours give a distinct look.

What sets this version of the G14 apart from its siblings isn't the laptop but the extras in the box. Or rather the box itself. It doubles as a sort of synth or mixing pad, connecting to the laptop via USB-C and working with a dedicated app on the laptop to allow music content creation. Touch-sensitive pads on the box include controls for track speed, sample loading, and sound effects. These tie in with visual effects that can be run on the laptop's screen or output to an external display.

How well it works from a music content creation perspective is debatable, but it's a fun extra that adds to the sense of this being a special and unusual laptop, rather than a spec-led, box-ticking affair. That's probably just as well because at least in one area the spec is slightly disappointing. Highlights include the eight-core AMD Ryzen 9 5900HS CPU, which is incredibly powerful. The 14-inch 2,560 by 1,440 pixel IPS display is a 120Hz beauty and a great compromise between detail and performance, though it could be a little brighter.

At least it would strike that balance between pixels and frame rate nicely if it were paired with a more powerful GPU. Asus has gone with an Nvidia GeForce RTX 3050 Ti for this special edition G14, despite the chassis being good for up to the RTX 3060 in other models. That's a pity because the 3050 Ti isn't up to the job of driving the display at native resolution at playable frame rates, let alone the panel's 120Hz refresh.

Admittedly, games still look pretty decent interpolated at 1080p. So, while it is a realistic option to drop the resolution down a notch and release a few frames, an RTX 3060 would round the package out much more effectively and make for a better match for the high refresh display. Moreover, this isn't the kind of system that's aimed at price-sensitive buyers. The fact that you can have a 'regular' G14 with 32GB of RAM and an RTX 3060 GPU for around the same kind of money probably doesn't matter to this laptop's niche target market.

The extra cost of the 3060 would hardly make a major impact on its appeal. That said, this is still a gorgeous laptop with fantastic design and build quality, plus a battery life of over eight hours in PCMark 10, especially given the huge CPU power on offer. The sound from the integrated speakers rivals Apple's MacBook's for dynamic range and quality, and there's some real bass on offer, albeit not so much outright volume. A bit more punch would be appreciated.

	Asus ROG Zephyrus G14 Alan Walker Special Edition
3DMark Fire Strike	12,665
Cinebench R20 Multi-core (points)	4,962
GeekBench 5 (single-core)	1,386
GeekBench 5 (multi-core)	7,379
PCMark 10 (points)	6,497
PCMark 10 Battery Life (h:m)	8:24
Video playback Battery Life (h:m)	9:40
Total War: Three Kingdoms (1080p, Ultra fps)	43
Metro Exodus (1080p, Ultra fps)	40

Lush build quality with an awesome CPU and fun music features.

Jeremy Laird

★★★★☆

$2,999 | au.msi.com

MSI GS76 Stealth

Potent power in a slick, stealthy chassis.

MSI is no stranger to 17-inch devices and the GS76 Stealth is certainly a looker, with some pretty hefty specs under the hood. Compared with the MSI GE76 Raider, this is a more slick and premium-feeling device. Finished in full-core black metal, it's one of the best designs we have seen from MSI.

It's pretty subtle for such a large device and that gives it an illusion of being smaller than it actually is. At a glance, and with the RGB keyboard turned off, you'd struggle to know that this was a gaming-focused laptop – it seems like a more mature step up from its GE76 Raider sibling.

The screen fits the chassis nicely too, with the same thickness of bezel around the sides and the top, and fitting a 720p webcam along the top edge. It's nothing too fancy, but this cam does allow for Windows Hello login, which is handy and does the job for the occasional zoom call.

Back to the screen, this model features the 360Hz Full HD IPS panel. It's not the punchiest of displays, with pretty low contrast, but that 360Hz refresh rate means it is super-snappy. There is a QHD screen in the range, with a 240Hz refresh rate, but we would opt for the model we have on test here. More than likely, you'll be using this laptop quite close to the display and will benefit more from the extra Hz and smoother feel in games.

Below this, you get a fairly deep air vent which is great for cooling, however, it does take up rather a lot of space at the bottom that could have been better employed for a larger mouse pad. Below the air vents is the impressive keyboard from Steelseries, featuring per-key RGB lighting. The keys deliver deep travel without feeling too spongy and yet still provide a satisfying click.

Fitted with a Dynaudio sound system, the GS76 Stealth delivers a deep and warm sound that is easily good and loud enough for media consumption. The mousepad, which is fairly narrow for a 17-inch laptop, has a soft finish and is perfectly good enough for everyday use. As for ports, the GS76 Stealth has plenty to offer with the power, ethernet, headphone jack, and two USB-Cs on the left. On the other side, there are ports for the HDMI, SD card reader, Thunderbolt 4, and USB-C.

Intel's i7-11800H is the brain behind this beast and powering alongside it is an Nvidia Geforce RTX 3070 card. It performed exceptionally well on the Crystal Disk scores, thanks to the PCIe Gen4 x4 NVMe M.2 SSD inside. Overall, it doesn't seem to struggle with anything we throw at it.

Thermals aren't too bad either, thanks to an array of cooling vents around the fan. If you are after flat-out power and a gaming aesthetic, MSI's chunkier, crazier sibling, the GE76 Raider, might be more up your street. However, if you want something that is still lightning fast but in a more premium package, then the MSI GS76 Stealth could be the one.

Specifications
CPU: Intel i7-11800H; Graphics: RTX 3070 8GB; 32GB DDR4 3200 MHz; Screen: 17.3-in 1080p @ 360 Hz; Storage: 1TB NVME M.2 SSD: Ports: 2x Type-A USB 3.2 Gen2, 1x Type-C USB 3.2 Gen2 (DP), 1x Type-C (Thunderbolt 4), 1x RJ45 Ethernet, 1x SD, 1x (8K @ 60Hz / 4K @ 120Hz) HDMI 2.1; Connectivity: Killer WiFi 6E AX1675 (2x2), Bluetooth v5.2, Killer E3100 2.5GbE LAN; Weight: 2.4Kg

Intel's i7-11800H is the brain behind this beast and powering alongside it is an Nvidia Geforce RTX 3070 card.

Ultra fast performance with premium design, tactile Steelseries keyboard and a speedy refresh rate.

Sam Lewis

★★★★½

$279 | www.razer.com

Razer Pro Type Ultra

Loud stabilisers ruin this "silent" mechanical keyboard.

Razer's new Pro Type Ultra is the latest in the company's more productivity focused gear lineup, which includes the original Pro Type, the Razer Pro Click and Pro Click Mini and even the Razer Book 13. To that end, it sheds most gamer-centric design trappings, like per-key RGB, while keeping enough to emphasise Razer's history with mechanical keyboards.

Even using this keyboard at home instead of at an office, I really like this less edgy design aesthetic. The finish on the Pro Type Ultra is gorgeous; the aluminium plate combined with the white ABS keycaps, which are prone to shine as they age but tend to have nicer looking legends than PBT, makes it one of the best-looking mechanical keyboards I have reviewed.

The keycaps on the Pro Type Ultra are also very chic and they go well with the silver finish on the keyboard's plate. It's definitely a step away from the keycap design we're accustomed to seeing from Razer but the exceptional visual quality is still there.

One of the biggest complaints that I had with the Huntsman V2 was the overly complex switch design, but with the Pro Type Ultra, we have the opposite. The stem on the Razer switches is a lot like the new TTC switches, as it features a dual sidewall, which allows for better keycap stability and less stem wobble.

TTC is a switch company, like Gateron or Kailh but not as well known. The company isn't new, but has just started blowing up in popularity thanks to its dual sidewall design instead of the standard MX cross or box stem. TTC switches have appeared in the Logitech POP Keys mechanical keyboard but can also be purchased separately on sites like Epomaker and KBDfans.

When I first started using the Razer Yellow Switches, I was bothered by how they weren't as quiet as the enthusiast-level silent switches that I am more accustomed to, like Gazzew Bobagums or Durock Dolphins. These switches do produce a mild squeak, but that's about it. Still, even if the Razer yellows aren't as quiet as church mice, their clacking is definitely more muted than on standard mechanical switches thanks to their rail stabilisers.

What is a big flaw when it comes to noise on the Pro Type Ultra is the stabilisers, because they are very, very bad. The stabilisers aren't as bad as costar stabilisers, but it just seems like Razer didn't put any effort into dampening their noise at all, and on a silent keyboard, that's important. You're going to get a ton of clacking and rattling every time you press the spacebar here.

Razer's Pro Type Ultra is a clear indication that the peripheral and laptop maker wants to start delivering to a more professional audience. But while the Pro Type Ultra definitely succeeds when it comes to looks, the ticking stabilisers are a serious blow to its attempt at a silent operation.

When I first started using the Razer Yellow Switches, I was bothered by how they weren't as quiet as the enthusiast-level silent switches that I am more accustomed to, like Gazzew Bobagums or Durock Dolphins.

It looks great and has good battery life, but we can't quite get used to the unpleasant sounds it makes.

Myles Goldman

★★★☆☆

$869 | www.teamgroupinc.com

Teamgroup T-Force M200 4TB Portable SSD

NVMe-like speeds over USB.

Specifications
USB 3.2 Gen 2x2 20Gbps connection; Up to 2,000 MB/s sustained read, 2,000 MB/s sustained write; Weight: 83g; Dimensions: 105(L) x 55.5 (W) x 11 (H) mm.

External SSDs aren't a new product category, but the combination of faster USB connections and denser NAND is leading to a new crop of ultra-fast portable drives. The Teamgroup M200 is one such drive. It aims to deliver pocket-sized portability, up to 8TB of storage, and performance that makes a mechanical HDD snail like in comparison. Though as you'd expect, the best external SSDs carry a hefty price premium.

The design of the M200 is reminiscent of a rifle magazine. It's made with a combination of metal and plastic and it's well built. It should be durable enough to slide in and out of bags or briefcases for a long time. Team says the drive is built to survive a two-meter drop and it's got a five-year warranty.

The key feature of the M200 is its USB 3.2 Gen 2x2 connection, which delivers a 20Gbps maximum transfer rate. This allows the M200 to reach NVMe -evel speeds. A sustained transfer speed of 2GB/s is outstanding for an external drive. We compared the M200 to a Samsung 860 Evo SATA drive; not surprisingly, it cannot hold a candle to the M200 in sequential transfers, which is the most likely use case scenario for the M200. An external HDD might be a lot cheaper, but it'll be around a 1/10th of the speed.

At $869 for the 4TB M200, it's a pricey proposition but there are few competing 4TB options. A drive that lets you transfer at 2GB/s goes a long way to justifying its expense. Make sure you use a 20Gbps connection to get the best out of it though.

The M200 is a very fast drive, but it's important to use it with a 20Gbps USB connection to justify its expense.

Chris Szewczyk

★★★★☆

	Teamgroup M200 4TB	Samsung 860 Evo 1TB SATA
Crystal Disk Mark - Sequential Read MB/s	1,904	560
Crystal Disk Mark - Sequential Write MB/s	2,024	527
Anvil Storage Utilities - 4K Random Read MB/s*	37.5	35.7
Anvil Storage Utilities - 4K Random Write MB/s*	66.5	83.1
Anvil Storage Utilities - 4K Random Read IOPS*	9,597	9,139
Anvil Storage Utilities - 4K Random Write IOPS*	17,017	21,276
Internal File Copy - 30GB of mixed file sizes	75	132

*Queue Depth 1

$159 | www.deepcool.com

Deepcool CK560 ATX

A value for money case with loads of cooling potential.

Specifications
Materials: Steel, tempered glass; Dimensions: W: 230mm H: 471mm D: 456mm; Weight: 8.0Kg; Front I/O Ports: 1x USB 3.1 Gen 2 Type-C, 2x USB 3.1 Gen 1, 1x 3.5mm combo headset jack; Cooling: 3x front 120mm fans, 1x rear 140mm fan.

Deepcool has developed a reputation for developing no frills products with a focus on value for money. But that line of thinking doesn't do the CK560 justice. In no way does the CK560 give the impression that it's a cheap case.

The CK560 is a mid-tower with a steel construction and a tempered glass side panel. The front features a magnetically attached cross pattern plate that ends up hiding a lot of the RGB lighting. Overall the CK560 is well built. There's plenty of dust filtration and you get a range of cooling configuration options. At 8KG its not overly heavy. The rear 140mm fan at the rear adds some extra width compared to many mid towers.

The CK560 comes with three preinstalled ARGB fans in the front in addition to the 140mm non-RGB fan at the rear. You can install a 360mm radiator at the front and a 280mm one at the top. The front ports consist of two USB 3.2 Gen 1 and one USB 3.2 Gen 2 Type-C along with a single audio/mic combo jack.

System assembly is straightforward. There's adequate space behind the motherboard tray for cable management and we like the adjustable GPU support bracket. Note that a 360mm AIO in the front can be a squeeze, though with a bit of pre-install planning for your cables, you'll be fine.

At around $159 The Deepcool CK560 blends value for money, quiet operation and capable cooling. It doesn't reinvent the wheel but it's got enough going for it to win a recommendation. It's a well built and sturdy case that will suit a wide variety of builds.

The Deepcool CK560 is a well-built case that features excellent cooling capacity without the big brand name price tag.

Chris Szewczyk

★★★★☆

$389 | dell.com

Dell S2722DGM

An affordable 1440p gaming monitor.

In theory, the new Dell S2722DGM is pretty much the perfect affordable gaming monitor. It's fast, cheap, has plenty of pixels, decent panel spec, and doesn't bother with frills and features that add little to the gaming experience.

It's built around a 1440p 27-inch VA panel with decent specifications. VA tech tends to be cheaper than IPS and with that come pros and cons. The most obvious advantage is static contrast. Dell rates this monitor at 3,000:1, which is almost three times better than any IPS monitor. However, despite the strong contrast, this is a straight-up SDR display with no HDR support. We're fine with that, given most so-called HDR PC monitors are nothing of the sort. Brightness is pegged at 350nits, which is fine for an SDR display.

The other major differentiator between VA and IPS is speed, as VA tends to be slower. The S2722DGM's pixel response is rated at 2ms GtG and 1ms MPRT, just behind the 1ms and 0.5ms ratings of the best IPS panels. Dell provides figures for how response performance relates to the user-configurable overdrive settings in the OSD menu. The other metric for speed is refresh. The S2722DGM is good for 165Hz, which is plenty.

The S2722DGM's 1440p native resolution equates to 2,560x1,440 pixels. On a 27-inch screen, that's a reasonable pixel density without generating the debilitating GPU load that comes with 4K. As for the Dell S2722DGM's broader feature set, don't expect too many extras. USB-C connectivity doesn't feature, but the dual HDMI and single DisplayPort connections are fine, even if the HDMI ports top out at 144Hz rather than 165Hz.

The Dell S2722DGM is a punchy and vibrant monitor considering it's a pure SDR panel. The strong inherent contrast helps, ensuring you aren't shortchanged when running games that support HDR, such as *Cyberpunk 2077*, in SDR mode.

So, the Dell S2722DGM does eye candy just fine. It's also quick enough to deliver where speed matters most. But we'd steer clear of MPRT overdrive mode, which hammers the panel's brightness and vibrancy. 'Extreme' mode, rated at 2ms, suffers from a whiff of overshoot, but it's only just visible in-game, while 'Super fast' resolves the overshoot but allows a little smearing of darker tones.

Meanwhile, the 165Hz refresh ensures lag is a non-issue and adaptive sync is catered for via AMD FreeSync Premium certification. Owners of Nvidia GPUs will need to run in basic G-Sync compatibility mode, which in practice is just fine.

All told, the Dell S2722DGM isn't as quick as the best IPS monitors, but nor is it a slouch. For similar money, you could go with a fast 1080p IPS panel, but we'd lean towards giving up a bit of speed for the added pixels and visual detail of this Dell. That's especially true if you factor general computing into the equation. 1440p on a 27-inch panel makes for adequate pixel density for mundane tasks like font rendering and desktop space. 1080p is pretty low rent.

Specifications
Panel size: 27-inch; Panel technology: VA; Native resolution: 2,560 x 1,440; Aspect Ratio 16:9; Refresh rate: 165Hz; Response time: 1ms MPRT, 2ms GtGHDR; Contrast: 3,000:1; Colour: 99 percent sRGB: Brightness 350cd/m2; Video Inputs: DisplayPort 1.2 x1, HDMI 2.0 x2; Other: AMD FreeSync Premium.

Dell rates this monitor at 3,000:1, which is almost three times better than any IPS monitor. However, despite the strong contrast, this is a straight-up SDR display with no HDR support.

Decent overall image quality with strong contrast, reasonably quick though no HDR.

Jeremy Laird

★★★★☆

$1,599 | hp.com

HP Z43

Productivity on a massive scale.

HP's pro line of "Z" monitors is bigger than ever before. The HP Z43 clocks in at a hefty 43 inches, but its size isn't the only way it differs from other HP Z screens. It's also more purely productivity oriented than some of the other members of the Z family, thanks to lower colour fidelity.

At the core of the Z43 is a 42.5-inch IPS panel with full 4K resolution and 60Hz refresh. We've seen plenty of superficially similar 43-inch class 4K monitors before. But they've tended to have the feel of a cheap TV rebadged as a monitor, maybe with DisplayPort added for more PC-centric connectivity. With that in mind, it's not surprising to find most of those displays run VA panels, which is what you'd expect in an affordable 4K TV.

Anyway, that's not the case here. The Z43 isn't a quick-and-dirty TV adaptation but is clearly a high-quality product. All the relevant input options are covered and each supports the display's full 4K@60Hz capabilities. There's both DisplayPort and mini-DisplayPort, plus HDMI and USB Type-C with DisplayPort Alt mode. The latter also delivers up to 65W of power, allowing for single-cable connectivity to laptops. What's more, with two USB-A inputs on the rear panel, plus a USB-A and USB-C located on the side, you have full hub capability when driving this monitor via USB-C.

Specifications

Panel size: 43-inchPanel technology: IPS; Native resolution: 3,840 x 2,160; Aspect Ratio: 16:9: Refresh rate: 60Hz; Response time: 8ms GtG: HDR: No; Contrast: 1,000:1; Colour: 96 percent sRGB; Brightness: 350cd/m2; Video Inputs: DisplayPort 1.2 x1, Mini_displayPort 1.2 x1, HDMI 2.0 x1, USB-C with DP alt x1.

But what about image quality? Overall, the Z43's panel specs are pretty modest once you get past the huge size and 3,840 x 2,160 native resolution. Peak brightness is 350 nits and there's no HDR support – this is a pure SDR panel. Static contrast is pegged at 1,000:1, which is fine, but not at the cutting edge, even for an IPS panel, let alone VA.

Then there's 60Hz refresh and 8ms response, which might seem a little sluggish, but is actually fine for a productivity panel. Less impressive, especially for an IPS panel, is the mere 96 percent coverage of the default sRGB colour space. All told, then, this is a slightly old-school IPS panel on paper. And that's how the Z43 looks when you fire it up. It's not hugely vibrant and the colours don't especially pop.

It's worth noting that the colour space presets available are limited, so calibration is needed to set most gamuts. The limited sRGB coverage rating means you won't get extensive coverage of demanding gamuts such as AdobeRGB or DCI-P3.

In that sense, this isn't really a monitor for pro content creation. It's a big screen with great connectivity designed for maximising productivity. And it does that well, with one exception. At this size, even 4K makes for big pixels and a poor density of 103dpi. If you want crisp and clean fonts and lots of image detail at close quarters, this isn't the panel for you. Nor is it a great choice from a value perspective. If you can live without the USB-C hub, you can have a 43-inch 4K monitor for less than half the money.

But what about image quality? Overall, the Z43's panel specs are pretty modest once you get past the huge size and 3,840x2,160 native resolution. Peak brightness is 350 nits and there's no HDR support – this is a pure SDR panel.

Really nice build quality with great connectivity, though low pixel density.

Jeremy Laird

★★★★☆

$519 | www.lacie.com

LaCie 2TB Portable SSD

Seagate's premium sub-brand costs more but hardly justifies the extra outlay.

Compared to some of its predecessors like the 2019 edition (LaCie Portable SSD 2TB), it is more compact although we're not sure about the thought process that convinced the designers to choose the parallelogram as the inspiration. It's worth – at this stage – mentioning the French origins of LaCie or La Compagnie and how aesthetics was at the core of its mission.

Before its acquisition by Seagate in 2014, the company had carved itself a lucrative niche amongst like-minded designers (and creative professionals) looking for creatively-inspired peripherals that could perform, regardless of the price. Trendsetters like Neil Poulton or Philip Stark collaborated with LaCie to design some iconic products. So the adage, beauty lies in the eye of the beholder, holds truer than ever in this case.

The drive itself is presented as a monoblock of machined aluminium with a Type-C connector at one end, a status light and the LaCie logo etched. Minimalist and stylish at the same time, it is also small enough to be carried around unnoticed (10.6mm x 50mm x 80mm for a weight of 45g). Inside the box is a USB Type-C cable, a 1-month subscription to Adobe Creative Cloud and details for Seagate's Rescue Data Recovery services.

The LaCie 2TB Portable SSD is built to last and should be able to withstand shocks and knocks. Just be mindful that the metal surface can and will get scratched if it falls on something that's abrasive (think concrete floor). Note that it doesn't have any IP rating, which means that it is not waterproof or dustproof. That puts it at a disadvantage compared to others.

Seagate promised read speeds up to 1.05GBps and write speeds up to 1GBps. We notched 1.05MBps (read) on CrystalDiskMark and 1.04GBps on write using the same benchmark. Other benchmarks reported slower numbers while a single 10GB file was transferred in 17.6 seconds (or a real life speed of 574MBps), slightly faster than the Seagate OneTouch Pro.

When it comes to sheer numerical tests, the drive itself performed in line with our expectations. Seagate promised read speeds up to 1.05GBps and write speeds up to 1GBps. We notched 1.05MBps (read) on CrystalDiskMark and 1.04GBps on write using the same benchmark. Other benchmarks reported slower numbers while a single 10GB file was transferred in 17.6 seconds (or a real life speed of 574MBps), slightly faster than the Seagate OneTouch Pro.

We suspect that the latter and the LaCie drive share at least some components. The storage device didn't warm up significantly during our tests and perhaps the only small complaint we could put through is the short length of the bundled cable.

To put it succinctly, the LaCie 2TB Portable SSD is too expensive for its own good. Yes, it comes with the data recovery services but so do cheaper and equally fast Seagate SSD drives of the same capacity. Can this conundrum be solved? We're not sure.

A great looking a solidly built drive, and includes free data recovery services.

Desire Athow

★★★½☆

$449 | www.dahuasecurity.com

Dahua LM32-E200C

Big in China but not so known in Australia, what's Dahua's 32-inch gaming monitor like?

Dahua is a big-in-China manufacturer that makes many things and is particularly renowned for its surveillance cameras. Now it's launching a gaming monitor into Australia, so we were keen to see whether it could make a dent or offer a great, new, value proposition. We were suspicious of the latter claim as the primary benefit is listed as, "Light and cost-effective plastic housing" but we kept an open mind.

The LM32-E200C comes in three pieces, which are assembled with a screwdriver. The wide, V-shaped base attaches easily enough but connecting the panel to the stand uses an unusually intricate design. This initially concerned us about its weight-bearing capabilities, but it held fast in our testing. It all amounts to a well-planted screen although only tilt adjustment is available.

Connectivity is basic and comes in the form of two HDMI ports and two DisplayPorts. The latter may cause issues with laptop users, who mostly use USB-C connectors for DisplayPort nowadays; but this is only really an issue if you want to take advantage of the screen's maximum refresh rate.

The 32-inch, lightly curved (1500R), Full HD panel can push up to 165Hz if you're using DisplayPort (HDMI is limited to 144Hz). We were keen to test performance but first impressions were mixed. After booting up, we were quickly reminded that a 32-inch screen is not ideal for a Full HD resolution: the Windows Desktop's icons are all oversized and the text that labels them is spidery and ill-defined. We also felt that colours and contrast were washed out, but after tinkering with the OSD settings and switching from Standard to Web mode, both characteristics instantly improved. Ultimately, it's not ideal for work unless you've poor eyesight and want everything magnified, but even then you'd be better off with a UHD monitor and then magnifying Windows Desktop.

We won't dwell on work performance as this is a multimedia and gaming monitor. When watching multimedia, we were impressed with the colours and, for the most, part contrast. However, we did keep having to fiddle with the monitor's menu options to get the best results for each media type. Doing this isn't the simplest task as you need to reach under the monitor and feel for the four, stiff, unlabelled buttons and navigate through lengthy on-screen menus each time. While we got used to the navigation, we were still annoyed at how often we needed to do it.

Gaming was a mixed bag. The 165Hz refresh rate is certainly smooth but we're not convinced about the pixel response times. Motion regularly produced a slight smearing effect in fast-and-frantic encounters. There are settings to adjust the pixel response time – which slightly improved matters – but we got tired of constantly doing that.

Ultimately, it feels like a cheap, functional gaming monitor so we were disappointed to see the high $449 RRP, which is almost double the cost of top-brand rivals with similar spec products on offer.

Specifications
32-inch, matte, 1,920 x 1,080, 8-bit, 165Hz, curved (1500R) LCD. 1ms MPRT. 250 nit brightness. 4,000:1 contrast. 2x DisplayPort 1.4, 2x HDMI 2.1. Tilt -5°+10°. 710 x 419 x 131mm, 8.7KG.

Gaming was a mixed bag. The 165Hz refresh rate is certainly smooth but we're not convinced about the pixel response times.

A cheap monitor that's overpriced.

Nick Ross

★★☆☆☆

$399 | www.gigabyte.com

Gigabyte Radeon RX 6500 XT Eagle

Where's the beef?

The Radeon RX 6500 XT is a card that we desperately hoped would restore some sanity to the GPU market. Extremely inflated prices caused by supply shortages, pandemic disruptions and mining demand has killed any possibility of a current generation GPU purchase for vast swathes of gamers. The 6500 XT is promoted as being a 1080p capable card at an affordable price, but AMD's quest for a budget hero has resulted in a card that's stripped to the bone. So much so that it struggles to compete against cards that are several years old.

The RX 6500 XT is an RDNA2 based card based on the 6nm Navi 24 GPU with 1024 shaders. Its 107W TDP is worth a mention, but it still requires external power. The 6500 XT sports a high clock speed and our Gigabyte Eagle sample was able to maintain over 2700 MHz, but that's about all that's worth highlighting in terms of specs.

The card is severely hampered by its 4GB of memory and 64-bit bus, despite its 16MB of Infinity Cache. Even at 1080p that can result in bottlenecks in current games. Then there's the PCIe x4 connection. At PCIe 4.0 we could live with that, but this is a budget card which means it's going to go into budget systems with PCIe 3.0 slots and probably a few PCIe 2.0 machines as well. Some gamers might not realise they could get a downgrade in performance compared to their old 16x card. We don't like the dual display limitation. Then there's the video engine compromises, which limit its usefulness for HTPC enthusiasts and streamers.

Specifications
1024 Shader Units; 2610MHz Base Clock, 2815MHz Boost Clock; 4GB GDDR6 18Gbps memory, 144GB/s Memory Bandwidth; 1x DisplayPort 1.4, 1x HDMI 2.1; 1x 6-Pin Power Connectors, 107W TDP.

The 6500 XT can offer decent performance in the right games. Just don't try running anything with ray tracing. If you're desperate for a GPU and you play older games or e-sports titles that won't run into memory limitations then the 6500 XT might appeal.

That's the positive spin. We compared it to the Radeon RX 6600 which is simply miles ahead in performance while the GTX 1660 also easily sees off the 6500 XT. The 6500 XT doesn't improve over the last generation RX 5500 XT and doesn't pull far ahead of cards like the RX 480 or GTX 1060. And both of those are close to six years old!

We could totally understand things if the 6500 XT was priced right. It's not. A tiny 107mm² GPU with a simplified PCB means AMD should be able to produce the 6500 XT at low cost. But at the time of writing, many cards were priced at well over $400 and some over $500. Ridiculous! Someone along the supply chain is making huge money. We've simply run out of patience. We'd be praising it if it was a sub-$200 card that destroyed something like a GT 1030, but that hope has been dashed.

The 6500 XT is quite simply a poorly executed product. It's not a stellar gaming card, it doesn't appeal to HTPC users or content creators and its dual monitor support limits its usefulness in productivity, workstation and office use cases.

If it was under $200, we'd say it's definitely worth a look, but at $400 or higher, its compromises leave us struggling to find a reason to buy it.

	Gigabyte Radeon RX 6500 XT Eagle	Powercolor Fighter Radeon RX 6600	Asus Phoenix GeForce GTX 1660
Metro Exodus Enhanced - 1920x1080 High Preset - Avg	17.4	[illegible]	N/A
Far Cry 6 - 1920x1080 Ultra Preset - Avg	56	[illegible]	65
Ghost Recon: Breakpoint - 1920x1080 High Preset - Avg	82	[illegible]	91
F1 2021 - 1920x1080 High Preset - Avg	114	[illegible]	132
3DMark - Time Spy	5,492	[illegible]	5,956
Temperature - Load (C)	62	[illegible]	77
System Power Consumption - Watts	217	[illegible]	231

The 6500 XT's compromises and inflated price make it impossible to recommend.

Chris Szewczyk

★★½☆☆

$349 | www.intel.com

Intel Core i5-12400

The new budget champ is here.

Intel's 12th Gen Alder Lake CPUs represent a return to form for Intel. The K series CPUs, while offering class leading multi-threaded, lightly threaded and gaming performance, aren't really mainstream options though. But that's changed now that affordable 12th Gen CPUs are here. Intel is now set to dominate the low to mid-range CPU market. We loved the 11th Gen i5-11400 and the i5-12400 we're reviewing here is even better.

The i5-12400 is a 6C/12T design. It omits E cores leaving the higher performing Golden Cove P cores only. This means it might not be a multi-threaded monster compared to CPUs with a higher core count, but the strengths of the P cores remain, meaning it should excel at gaming tasks, where IPC is more important.

The 12400 comes equipped with Intel's Xe UHD 730 graphics. It features a 65W TDP with a 117W maximum turbo limit. This is much lower than the 154W of the 11400. Intel's 10nm process is clearly working well. Its base clock is 2.5GHz with a 4.4GHz boost clock. The 12400 comes with Intel's redesigned Laminar RM1 cooler, which is a dramatic step up in quality and its perfectly usable with the 12400.

We tested the 12400 with the RM1 cooler and the stock power parameters applied. Under a full 12-thread load, the whole system pulls just 159W from the wall. We don't often talk about Intel and power efficiency in the same sentence, but that's an excellent result. We also used an MSI B660 DDR4 motherboard, so, if you're after an affordable system, you can save big by not wasting money on DDR5 memory and an aftermarket cooler.

If you do choose an aftermarket cooler you can remove the default power limits for some extra performance. For example, the 100 percent stock 12400 scores 11,707 in Cinebench R23, while the 'unlocked' 12400 scores 12,350.

The 12400 and its six cores deliver excellent multi-threaded performance, though it's important not to expect miracles. If you need maximum multi-threading grunt, you're still better off with higher core count AMD CPUs or Intel's Alder Lake CPUs that include E cores. The real strengths of the 12400 come to the fore when looking at single or lightly threaded results and gaming.

The major strength of the 12400 is its gaming performance. It's able to beat the highly regarded 11600K and matches the AMD 5800X, even at its default settings with the bundled cooler! Bear in mind we're talking about a $349 processor here. In a market where value is very hard to find, you could grab a 12400, a B660 DDR4 motherboard, and use DDR4 from an older system and you'll have the core of a very capable gaming PC. You could take those savings and put it towards a better GPU for example.

The Core i5-12400 is easy to recommend. It offers energy efficiency and, unlike the more expensive 12th Gen models, it doesn't require a powerful cooling solution. It delivers strong lightly threaded performance and it's an excellent gaming CPU. Throw in great value for money and the features of the Z690 and B660 motherboards and the i5-12400 becomes our new favourite budget CPU.

Specifications
Intel Core i5-12400; LGA 1700 socket; 6 cores/12 threads; 2.5GHz base clock, up to 4.4GHz boost clock; 18MB cache; Supports DDR4-3200 or DDR5-4800; 65W base power, 117W maximum turbo power.

The 12400 and its six cores deliver excellent multi-threaded performance, though it's important not to expect miracles.

	AMD Ryzen 7 5800X	AMD Ryzen 7 3700X	Intel Core i5-11600K	Intel Core i5-12400
Cinebench R23 - Multi thread Score	15,588	12,126	10,493	11,707
Cinebench R23 - Single thread Score	1,583	1,278	1,524	1,729
Handbrake Video Encoding - Video conversion 4K to 1080p FPS	65	48.4	47.5	48.7
3DMark TimeSpy Extreme - Overall score	9,234	8,683	8,601	8,590
3DMark TimeSpy Extreme - CPU Score	9,716	4,535	4,426	4,403
Ghost Recon: Breakpoint - 1080p, Low, Avg FPS	217	193	212	215
Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Avg FPS	129.1	107.1	126.7	131.6
Metro: Exodus Enhanced Edition - 1080p, Ultra, DX12, Min FPS	77.5	66.9	75.8	77.6

The i5-12400 delivers excellent value, gaming performance, and energy efficiency. It's an awesome budget CPU.

Chris Szewczyk

★★★★★

CHOOSING THE RIGHT MOTHERBOARD FOR YOUR NEW INTEL PC

YOU MIGHT BE SURPRISED AT WHAT A LOWER TIER BOARD HAS TO OFFER.

2022 is shaping up to be a big year for PC upgraders. There's the forward looking 12th Gen Alder Lake platform with 13th Gen set to launch towards the end of the year. There's AMD's Zen 4 to come and for the first time in many years, a new socket: AM5. There's also the hope that we'll see Nvidia RTX 40 cards and AMD RDNA3 GPUs, though GPUs are a story for another day. There's every chance that a lot of our readers will be making major upgrades sometime this year. Your choice of motherboard is central to your upgrade path.

The motherboard is aptly named. It forms the core of your PC. The CPU, memory, storage, graphics, I/O devices and peripherals all connect to it. It's obviously a critical component. Choosing one can be difficult. And not just for the here and now. Your choice of motherboard could influence your upgrade path for years to come. There's a lot to consider. Choose wisely!

Let's begin with Intel. Z690, H670, B660 and H610 motherboards all support either DDR5 or DDR4. Z690 motherboards are the most feature rich. H670 is slightly less so while B660 focuses on a useful core feature set. H610 boards are very much entry level and have larger drawbacks.

PCIe 5.0 is an optional feature. Most premium boards will include it but cheaper B660 boards and H610 mostly lack support. PCIe 5.0 doesn't matter right now as even the high-end boards don't have PCIe 5.0 M.2 slots. PCIe 5.0 is less relevant for GPUs at this point in time.

Z690 is one for the enthusiasts

Z690 motherboards are well known at this point. They are a welcome upgrade over Z590, mostly as a result of the DMI 4.0 8x CPU to chipset link, which is double that of the DMI 3.0 8x link of Z590. Many chipset lanes are allocated to NVMe drive slots. The extra bandwidth makes it easier for motherboard makers to add 3rd party controllers including 5G or 10G LAN, more USB and SATA or Thunderbolt 4. These features are expensive, and with the current global supply chain issues, premium tier Z690 boards with all the bells and whistles approach and exceed

1 B660 boards are budget, but better than cheaper options of old

2 H610 is the cheap but not necessarily bad option

3 Z690 is the premium – and expensive – choice

4 H670 is a good mid-tier option

Choosing one can be difficult. And not just for the here and now. Your choice of motherboard could influence your upgrade path for years to come. There's a lot to consider. Choose wisely!

$1,000. Which is, of course, crazy!

Z690 boards support CPU overclocking via multiplier, while several high-end motherboards also support base clock overclocking, which is a bit of a grey area. It's unlikely anyone will pair an $800 or higher motherboard with a $200 CPU, but it's possible to run an i3 or i5 at over 5.0GHz on some models.

H670 is an in-betweener

H670 is essentially a trimmed down Z690 without CPU OC support. At the time of writing there were very few models available. It can be considered as something like Z690 lite, most notably lacking a few USB ports. It would seem that the retail focus is on either Z690 or B660 boards.

B660 boards aren't like the B series boards of old – they're much better

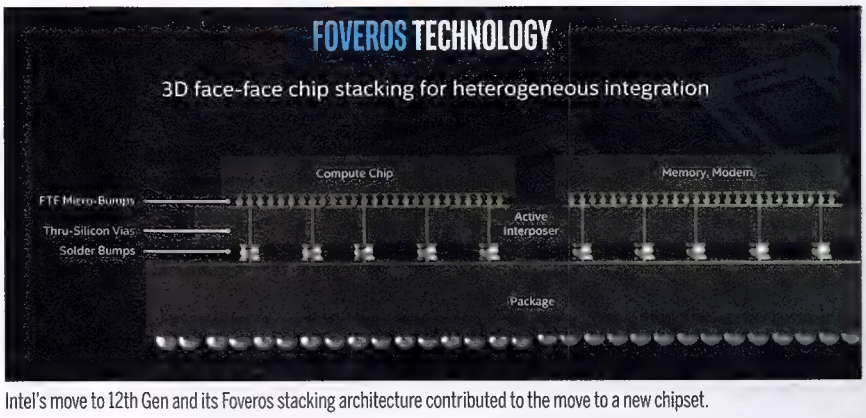
Intel's B series chipsets have made a big step up in quality. It began with B560, and it continues with B660. B460 and older boards were seen as very budget oriented, but that's all changed, perhaps in response to the qualities on offer from AMD's B550 chipset which doesn't lose significant functionality when compared to X570.

Premium tier B660 boards will be perfectly adequate for most users. At least if you don't plan to overclock your CPU. B660's main weakness is it halves the chipset to CPU DMI bandwidth from the 8x lanes of Z690 to 4x lanes. This means you can run fewer NVMe drives. If you plan to run three or more, Z690 is your best bet. B660 boards span a large price range. Basic boards are indeed basic, but the higher tier boards include things like Wi-Fi 6 or 6E, 2.5G LAN, a better USB complement, better audio and a stronger VRM with cooling suitable for powering 125W CPUs. The better B660 boards are often preferable to entry level Z690 boards.

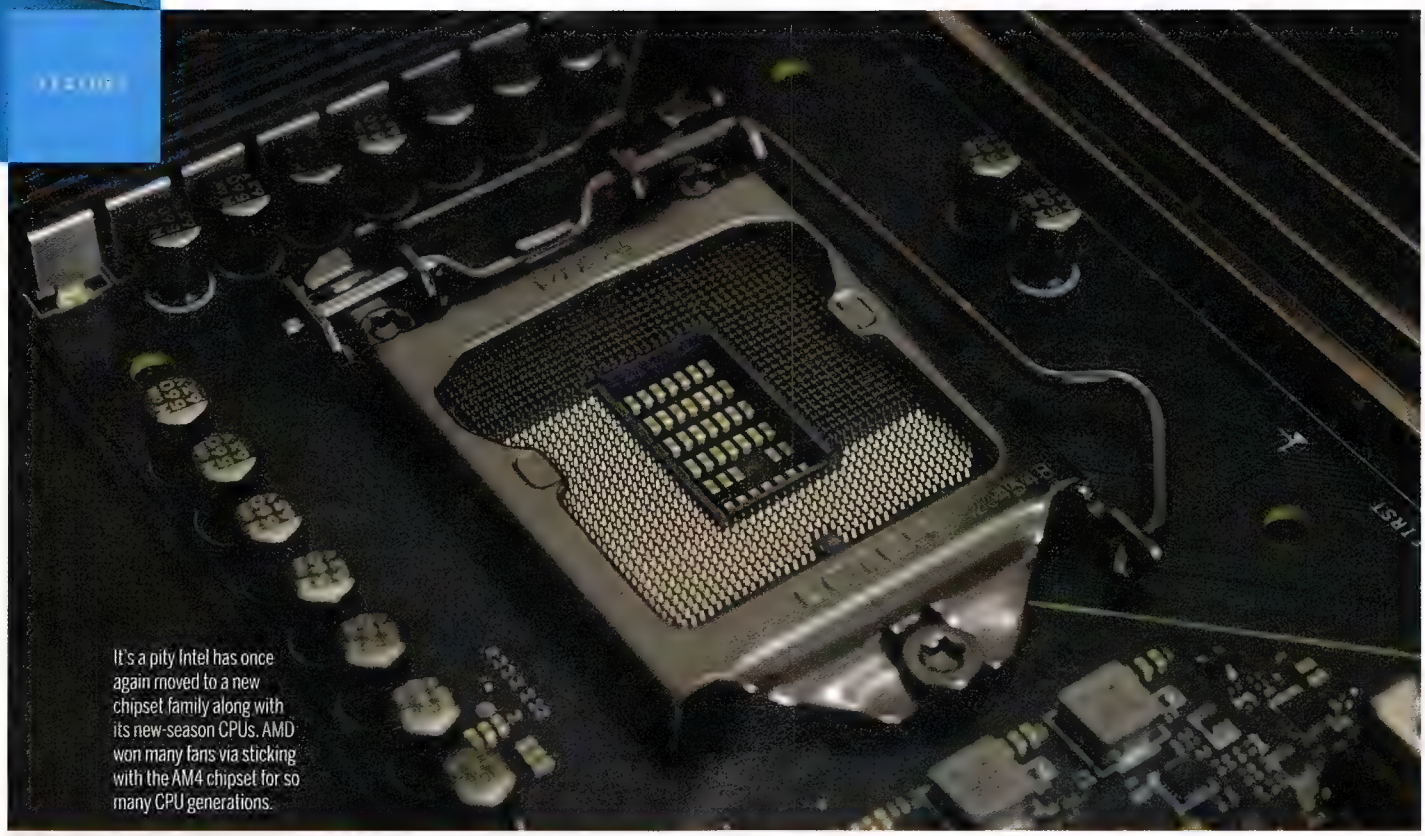
One of the major improvements introduced by B560 and carried over to B660 is support for memory overclocking; or perhaps more accurately, support for XMP speeds beyond minimal JEDEC standards. This means you can run DDR4 3600 in Gear 1 mode for optimal low latency performance, or you could run DDR5-6400 and higher (that's if you can find DDR5 in stock to buy). Of course, you can only choose one or the other. There are no DDR4 and DDR5 combo boards.

H610. Welcome to budget town

H610 motherboards are very much entry level. A DIY builder is probably going to skip these unless you're looking for a basic internet box or office machine. It will be perfectly happy with something like a 65W i3 or i5 but running a 125W CPU with a high PL2 power rating generally isn't recommended. H610 boards tend to have low quality VRM that can best be described as adequate. Some even lack MOSFET cooling altogether. They also have that pesky memory speed limitation.



Intel's move to 12th Gen and its Foveros stacking architecture contributed to the move to a new chipset.



It's a pity Intel has once again moved to a new chipset family along with its new-season CPUs. AMD won many fans via sticking with the AM4 chipset for so many CPU generations.

DDR4 boards will support up to DDR4-3200 while DDR5 boards support up to DDR5-4800. Given that a 2x16GB set of DDR5 likely costs more than a H610 board and CPU put together, that's not a recommended combo at this time. You're better off with an existing set of DDR4.

Having said that, there's nothing stopping you from running an RTX 3090 Ti on a H610 motherboard. If you run a single NVMe drive and GPU, you could save a lot of money over an expensive Z690 board with features you may never take advantage of.

A look into the crystal ball

The LGA 1700 socket and 600 series motherboards should allow forward compatibility with 13th Gen Raptor Lake CPUs which are due for launch towards the end of 2022. These are expected to be an evolution of current 12th Gen Alder Lake processors. Further out, 14th Gen compatibility is a bit of an unknown. Meteor Lake CPUs are fundamentally different, utilising Intel's Foveros packaging technology with a tile-based design. But, AMD managed not to break AM4 compatibility when it switched from a monolithic design to its chiplet design so it's likely Intel could engineer 14th Gen compatibility if it sets out to.

Don't be surprised to see a socket change though. It wouldn't be unexpected given Intel's inclination to change it every couple of generations.

Rumours indicate that 13th Gen CPUs will continue to support DDR4, although it's impossible to say with certainty this far out from the launch. But, our money would be on current 600 series motherboards with DDR4 memory being able to accept a 13th Gen CPU with a BIOS update at the end of the year.

What about AMD?

Socket AM5 is more of a topic for later in the year, however, there are some things we know about it. It will be the first AMD socket to support DDR5 memory. By the time it launches, hopefully DDR5 availability will be a lot better, and AMD should be able to take advantage of the fact that DDR5 will be an established technology by then.

The other key confirmed feature is cooling support. AMD has confirmed that AM4 coolers will retain compatibility with AM5. That's a weakness of Intel's socket 1700, which requires a new cooler or mounting for LGA 1200 and older coolers.

We are purely speculating, but it's likely AMD's chipsets will be led by X670, with B650 and A620 chipsets to follow in 2023.

AM5 will likely endure for several years. While forward and backward compatibility is spotty with AM4, we have hopes that a larger BIOS ROM will mean that AM5 motherboards will enable full forwards and backwards compatibility. It would be nice to be able to buy an X670 board and place a Zen 5, Zen 6 or maybe even Zen 7 CPU into it sometime in 2026 or even later!

Don't be lured into paying big dollars for features you may not need

With a few key considerations, and a careful examination of what you need from your system, both now and in the future, it's possible to make a more informed motherboard choice. Happy hunting! ■

INTEL 600 SERIES CHIPSETS

	Z690	H670	B660	H610
P and E Core overclocking	y	n	n	n
Memory Overclocking	y	y	y	n
Number of supported Memory Channels	2	2	2	2
DMI 4.0 lanes	8	8	4	4
Chipset PCIe 4.0 lanes	Up to 12	Up to 12	Up to 6	N/A
Chipset PCIe 3.0 lanes	Up to 16	Up to 12	Up to 8	8
SATA 6GB/s ports	Up to 8	Up to 8	4	4
Maximum Total USB 2.0 ports	14	14	12	10
Maximum Total USB 3.2 Gen 2x2 (20Gbps)	4	2	2	N/A
Maximum Total USB 3.2 Gen 2 (10Gbps)	10	4	4	2
Maximum Total USB 3.2 Gen 1 (5Gbps)	10	8	6	2
PCIe Storage Support	y	y	y	y
Integrated Intel Wi-Fi 6E	y	y	y	y
Intel Optane Support	y	y	y	n

$349 | www.msi.com

MSI MAG B660 Tomahawk WIFI DDR4

A 600-series motherboard that hits the sweet spot.

Now that you have a clearer picture of the 600 series chipset via the *APC* pages you've just enjoyed, you'll know that B660 is worthy of serious consideration. Intel B series boards are no longer cheap and forgettable. Many of them, like the MSI MAG B660 Tomahawk WIFI DDR4 we're reviewing here, carry feature sets that would have been restricted to high-end boards just a couple of years ago. At around $349, it's not what you'd call a cheap motherboard, but relative to some crazily priced Z690 options, it definitely is. Is the premium Tomahawk a board that you should consider instead of a cheap Z690 board?

We won't go over the B660 chipset too much. There are some limitations compared to Z690, but unless you plan to overclock or run a lot of M.2 storage, you'd hardly know the difference. You'll also need to look at the quality of the cheaper Z690 boards which can cut a few corners that shouldn't be cut. The MSI B660 Tomahawk mostly avoids those pitfalls, notably with its strong VRM, cooling and I/O.

The board looks like it takes aesthetic cues from MSI's Unify range. Both share a black, RGB-less, subtle design. There are four RGB headers though, including two that are addressable, so RGB is there if you want it. The Tomahawk comes with three PCIe slots. The primary slot is a 16x slot that supports PCIe 4.0, the second is a 16x slot (x4 electrical) that supports a PCIe 3.0 and finally a PCIe 3.0 x1 slot.

The Tomahawk will accept up to three PCIe 4.0 M.2 drives, though one of them only runs at 2x. Three slots will be sufficient for most users, but if you want four or more, you'll have to go to Z690. Don't forget the six SATA ports too. Notably, the three M.2 slots all have heatsinks.

Specifications
MSI MAG B660 Tomahawk WIFI DDR4; LGA1700 Socket; 3x M.2; 6x SATA; Up to 1x USB 3.2 Gen 2x2, 5x USB 3.2 Gen 2, 2x USB 3.1 Gen 1, 8x USB 2.0; Intel Wi-Fi 6; Realtek RTL8125B-CG 2.5G LAN; Realtek ALC1220P 7.1 Channel HD Audio; ATX Form Factor.

The B660 Tomahawk includes a 12+2 phase VRM powered by dual 8-pin power connectors. Bearing in mind that overclocking is not allowed on B660 boards, all it has to handle is the maximum power of a stock 12900K. It's all cooled by a pair of chunky black heatsinks. It's a VRM that won't have any trouble handling a stock 12th Gen load.

The rear I/O is a definite highlight of the board. You get Realtek 2.5G LAN and Intel WiFi 6 which will handle the networking needs of most typical users. There are nine USB ports made up of four USB 2.0, four 3.2 Gen 2 ports, and a 3.2 Gen 2x2 20Gbps Type-C port. The latter is a welcome inclusion in this price range. There's also a full set of audio ports and HDMI 2.1 and DP 1.4 ports.

The Tomahawk performed almost exactly the same as a Z690 Aorus Pro DDR4 board. DDR4 remains perfectly viable though, particularly in gaming tasks where DDR4's lower latency is advantageous. Fast DDR5 does tend to pull away from DDR4 in creativity benchmarks where raw bandwidth is preferable.

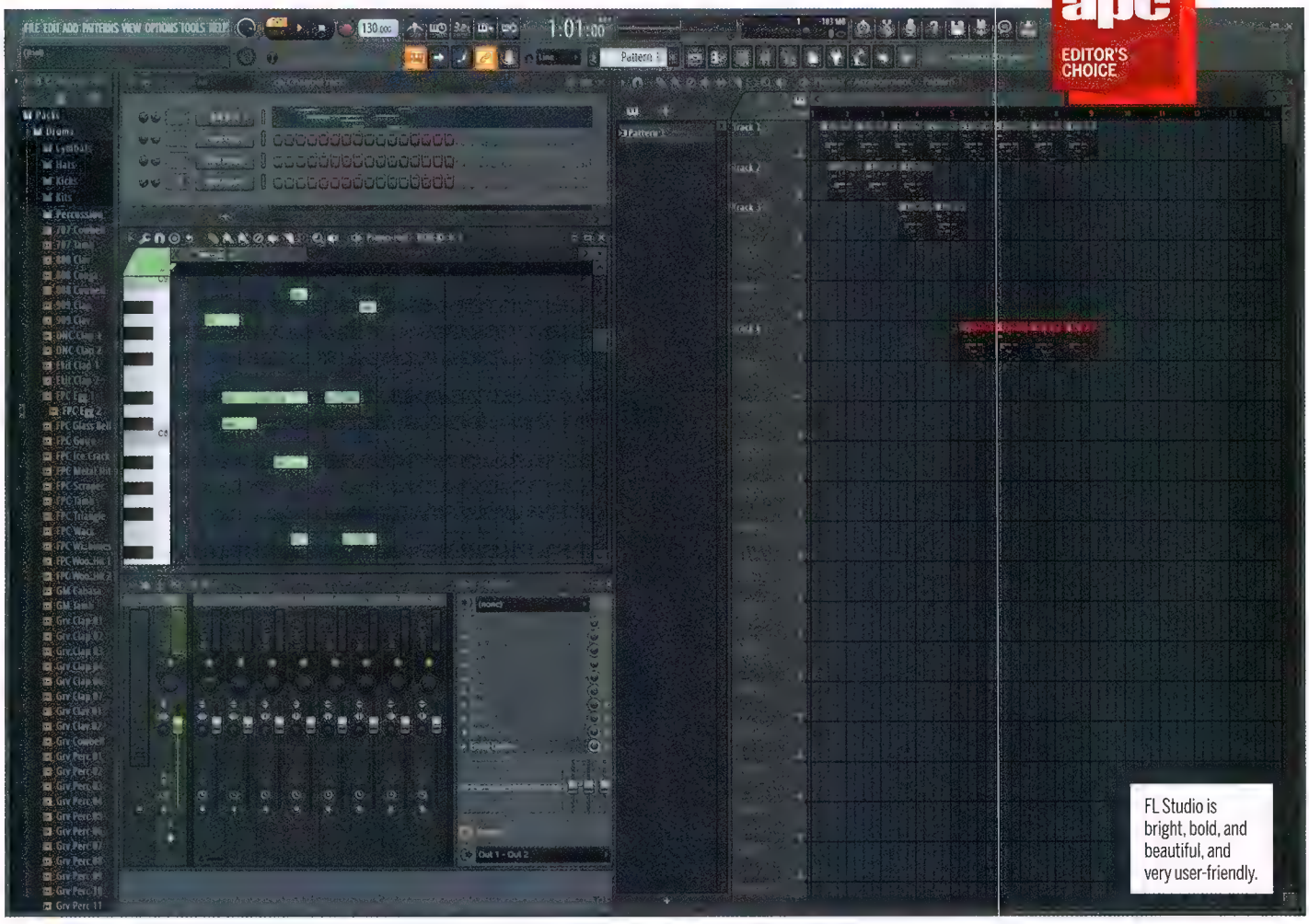
The MSI B660 Tomahawk DDR4 is a great value purchase that's well suited to a general user who runs a single GPU, an SSD and HDD or two, and doesn't care about CPU overclocking. That's probably 95 percent of the market. At $349 it's not what we'd call cheap, but in a market where a mid-range board is disturbingly $500 or more, it's a lot of board for the money.

	MSI MAG B660 Tomahawk DDR4	Gigabyte Z690 Aorus Pro DDR4
Cinebench R23 - Multi thread Score	17,454	17,435
Blender 2.92 Classroom - Time (seconds) Lower is better	398	399
7Zip - Million Instruction per second	86.67	86.61
Handbrake 1.4.2 - Video conversion 4K to 1080p FPS	64.1	63.9
Ghost Recon: Breakpoint - 1080p, Low, Avg FPS	225	225
Middle Earth: Shadow Of War - 1080p, Lowest Preset, Avg FPS	309	305
3DMark TimeSpy Extreme - Score	9,255	9286

A premium B660 motherboard that offers a quality core feature set without sacrificing value for money.

Chris Szewczyk

★★★★½



FL Studio is bright, bold, and beautiful, and very user-friendly.

WINDOWS APPS **FL STUDIO 20** | FL Studio Fruity Edition $139, FL Studio Producer Edition $289, FL Studio Signature Bundle $449, FL Studio All Plugins Edition $664 | www.image-line.com **PRO TOOLS** | Pro Tools one-year subscription US$399, Pro | www.avid.com

FL Studio 20 vs Pro Tools

Which DAW hits the right notes?

With creativity-based software, many of the most popular and market-leading programs have several alternatives that carry out the same tasks, whether that's graphic design, photo-editing, or music production. There may be lots of reasons to pick one over the other, including price, features, or accessibility but familiarity with the program, suite, or company you are currently using may be a powerful reason to stick with what you know.

While alternatives may offer a similar or superior product, that decision often comes down to what you feel most comfortable using. This applies to digital audio workstations (DAWs) too. A DAW allows you to compile a variety of different sounds, samples, and instruments together to complete a polished final track.

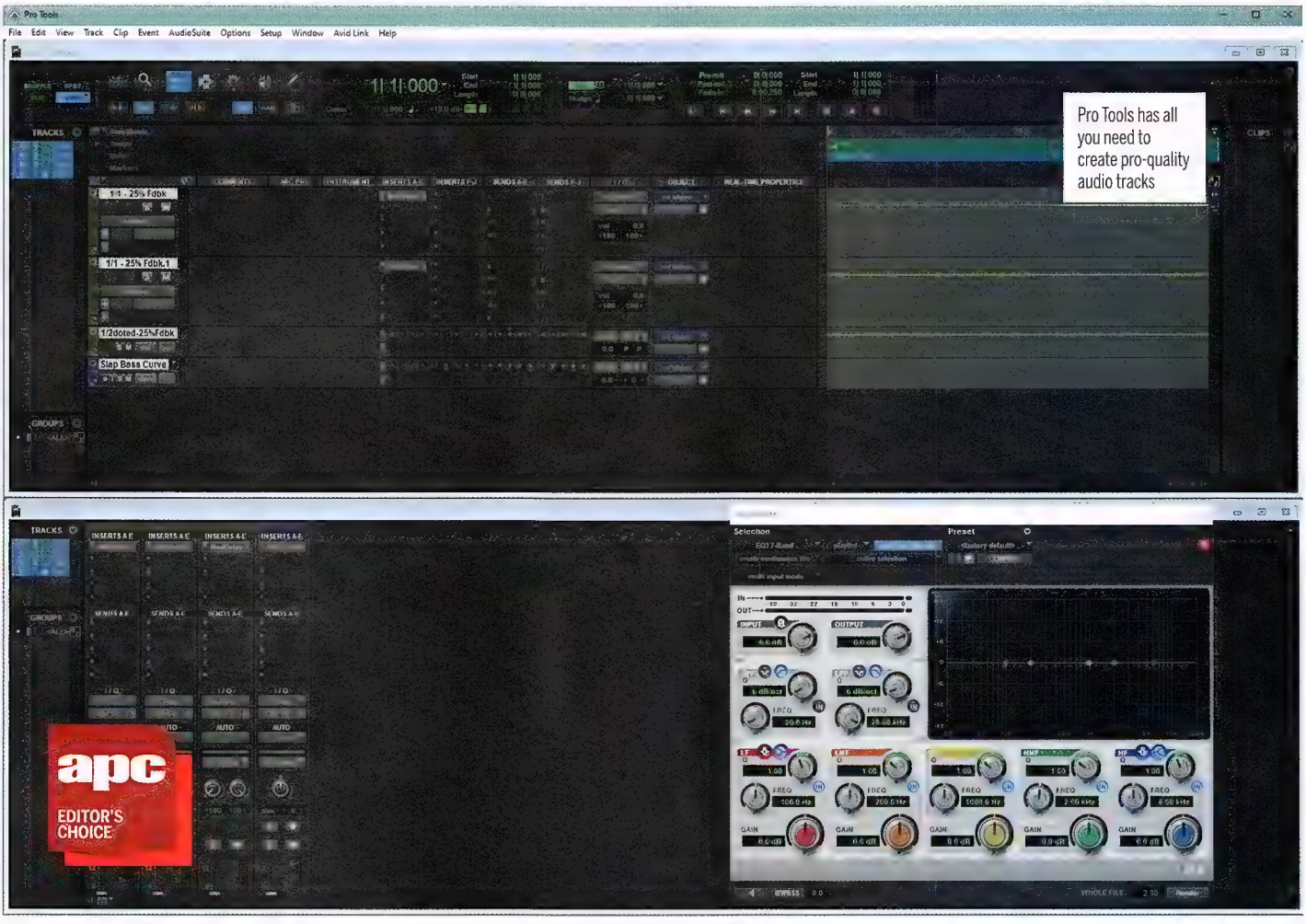
Both Image-Line's FL Studio 20 and Avid's Pro Tools are capable programs that deliver high-quality professional-grade audio, so which one should you pick if you are starting out? And, if you already use one, is it worth switching over to the other?

Avid's Pro Tools is considered the industry standard in digital audio workstations. Originally created by Digidesign, this piece of software has been through many variations and changes since it was first officially released under the Pro Tools name in 1991. Its popularity in the production industry has grown since then, and it has now become an essential tool for recording and mixing engineers.

Formerly known as FruityLoops, FL Studio began life at the end of the 1990s. This program was seen as a more introductory piece of software but, over time, it has become a professional-grade application with the potential to produce commercial audio. It was never initially intended for professional musicians, as the developers of the original Image-line software had no previous musical experience, instead their focus was on game design.

However, this different perspective is what made, and still makes, FL Studio so appealing – especially in terms of user interface design. The design language is vibrant, intuitive, and colorful. Its ease of use and 'friendly' styling harks back to the fact that Image-line came from a gaming background. At a time where most music applications looked as exciting as an Excel spreadsheet, FL Studio appealed to beginners. Although Pro Tools now has a clever UI, it still has a more corporate design that can be a little overwhelming. FL Studio's software feels more polished and user-friendly with its distinctive orange color scheme. Subtle design elements make the application an easier place to work. Both are pretty well organised DAWs, but Pro Tools' UI is a little sharper in some areas.

One main difference between these two DAWs is the price. FL Studio has four versions. The basic Fruity Edition costs $139



and comes with no audio clips or audio recording. Next up is the Producer Edition costing $289, which features audio recording, full playlist features, and six additional native plugins. The Signature Bundle costs $449 and comes with the same features, but has 13 additional native plugins instead of six.

At the top of the range is FL Studio All Plugins Addition, which has all of the native plugins for $664. This program certainly gets pricier the further you go up the range – factor in the additional packs, presets, samples, and loops, and you can end up spending a fair amount.

Avid's Pro Tools works on a subscription basis. There are two versions available, Pro Tools and Pro Tools Ultimate. The regular version is US$300 upfront or US$30 a month for a one-year subscription, and US$35 per month for a rolling monthly subscription. The Ultimate Edition comes with 192 (with HDX) channels of I/O compared to the regular 64. You also get 2,048 audio tracks instead of 256, and the addition of surround and immersive multi-channel mixing, instead of just mono and stereo.

The Ultimate edition costs US$800 per year, US$80 monthly on a yearly subscription, or US$90 on a rolling monthly basis. That works out pretty expensive, but both versions boast over US$1,600 worth of free plugins, sound libraries, and training content though, which is a great addition.

In our view, FL Studio wins this battle based on its value for money – but it also has a neat trick up its sleeve. Purchase FL Studio and you get free updates for life, so you'll always have the latest version. In some respects, you get what you pay for, Pro Tools is a more well-rounded product that sets the bar for others, including FL Studio. Industry-standard doesn't have to be the best priced or best designed, there is a reason why it is being used by many recording studios. FL Studio's popularity comes down to its design and quality features in a fun package. It's not just for beginners, there are plenty of producers using it, hence the multiple versions.

Although these DAWs can both create the same outcome, the main difference is the target market. Pro Tools is focused on a more commercial high-end studio production market, whereas FL Studio's ease of use appeals to a younger audience who are getting into the audio production world. That's not to undermine FL, as it's an amazing piece of software that in most cases will be all you'll need, but with its intuitive, colourful, and bold aesthetic, beginners can get to grips with the foundations of audio production in a seamless manner.

If you want to try and practice audio production, but are unsure of how it will progress, FL Studio is a great place to start. For a slightly more professional and commercial route, practice with Pro Tools. For overall performance with a higher level of control and quality, Pro Tools is the DAW for you and will provide you with everything you'll ever need.

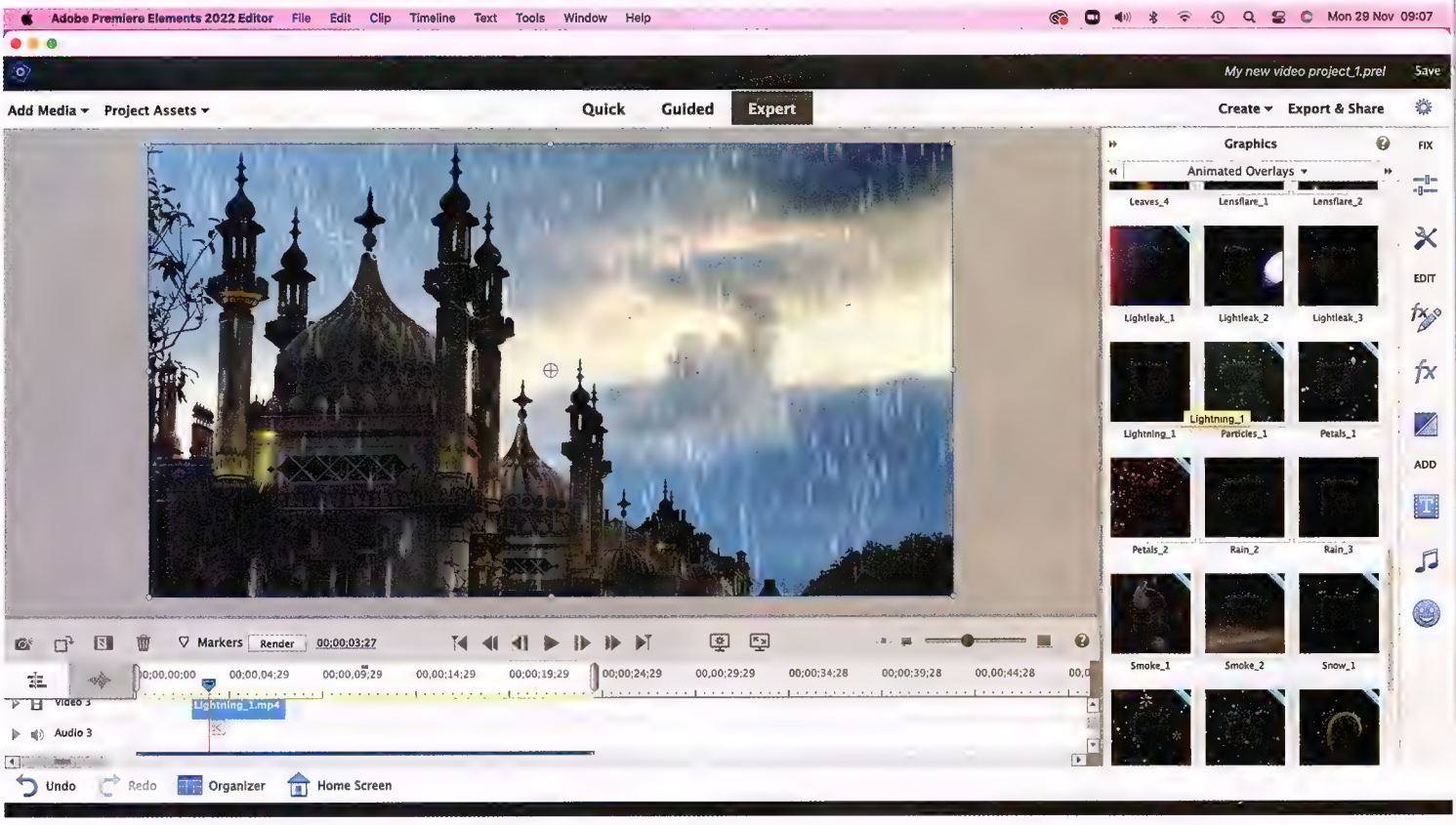
But for its great UI with lots of features, an intuitive style, FL Studio is a great place to start. In this battle of the DAWs, it has to be a tie – both offer great features at different price levels and are exceptionally good DAWs. It just depends on what level of production you are after. Both offer trials, so it's worth giving both a try-out to see which suits your needs.

FL Studio 20 Free lifetime updates; user-friendly; great piano roll, though the most powerful plugins only available in 'All Plugins Bundle'.

★★★★½

Pro Tools Industry-leading standard; plenty of features, but wallet-burning subscription costs; no upfront purchase option; design looks rather outdated.

★★★★½



MAC STORE & OTHER MAC APPS | macOS 10.15 OR LATER | $119 | adobe.com

Premiere Elements 2022

Turn footage into slick sequences complete with titles and effects

Thanks to our ever-present iPhone and its superb camera, we're likely to record more video clips than ever before, leading to the problem of organising and sharing our favourite footage. As a simplified version of Adobe's Premiere Pro, Premier Elements 2022 is an entry-level non-linear editor (NLE) that's designed to help video makers trim, fix and share their video footage as eye-catching clips and sequences that will generate those endorphin inducing 'likes' on sites such as Twitter and Instagram.

If Photoshop Elements and Premiere Elements are brother and sister apps, Elements Organiser is the parent. The Organiser enables you to view clips and images in one place and organise them using tools such as keywords and albums. All three apps are accessible from a handy welcome page. You don't need to own Photoshop Elements to enjoy using the Organiser as it ships with Premiere Elements (though you can buy both Premiere and Photoshop Elements together for a discount).

Workspace base

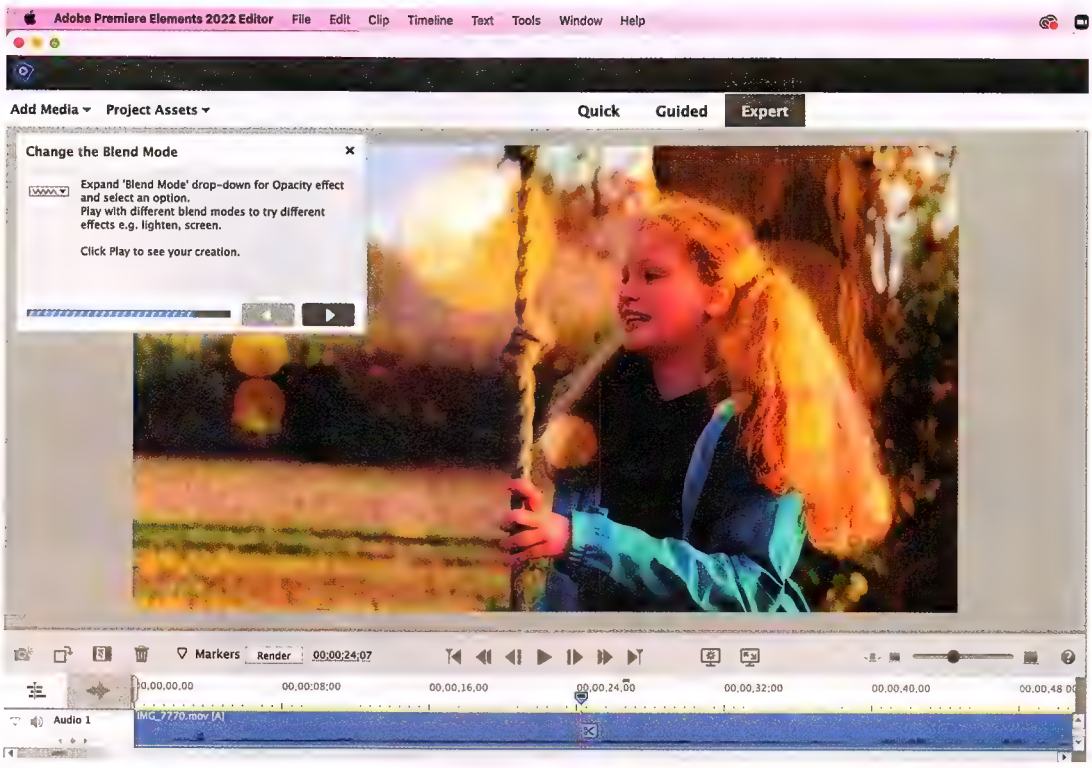
There's no noticeable difference to Premiere Elements 2022's light grey workspace compared with earlier incarnations, which will be comforting to those already using older versions. If you're familiar with Photoshop Elements, Premiere Elements will also look similar thanks to the same Quick, Guided and Expert workspaces.

The Quick workspace is where you can trim single clips or cut a few shots together in the timeline before sharing them as a sequence. The novice video editor should head over to the Guided workspace. Here 28 themed Guided Edits walk you through the video production process – from the basic tasks of importing, reordering and trimming clips in the timeline to adding post-production graphical elements such as titles and captions. Step-by-step text instructions are accompanied by handy pop-up highlights around various buttons and panels, so you can quickly learn how to find and use key editing tools.

Premiere Elements 2022 adds two new Guided Edits to its repertoire – Animated Overlays and Adjust Shadows and Highlights. The Animated Overlays guided edit teaches you to how to add effects such as falling leaves or floating bubbles to your video footage. You can also introduce weather-related elements such as rain, fog and even bolts of lightning!

The Animated Overlays Guided Edit also offers social media-friendly effects such as light-leakage and lens flares. Animated Overlay effects are also a new feature in Photoshop Elements 2022, though the Premiere Elements version doesn't offer the handy AI-assisted option of automatically placing the particles behind the main subject.

Premier Elements 2022 is an entry-level non-linear editor (NLE) that's designed to help video makers trim, fix and share their video footage as eye-catching clips and sequences that will generate those endorphin inducing 'likes' on sites such as Twitter and Instagram.



Left: New weather-themed animations change the look and mood of your clips. Here we've added lightning and rain elements on separate layers.
Right: The new Animated Overlay Guided Edit teaches you how to use layer blending modes, to add elements such as floating bokeh circles.

The new Adjust Shadows & Highlights Guided Edit introduces you to the selective tone tweaking tools in the Applied Effects panel. Here you can reveal more shadow detail without blowing out correctly exposed highlights, or claw back more detail in a bright sky without plunging a landscape into darkness. This Guided Edit may be new but the tools it covers aren't any different to those found in older versions of Premiere Elements.

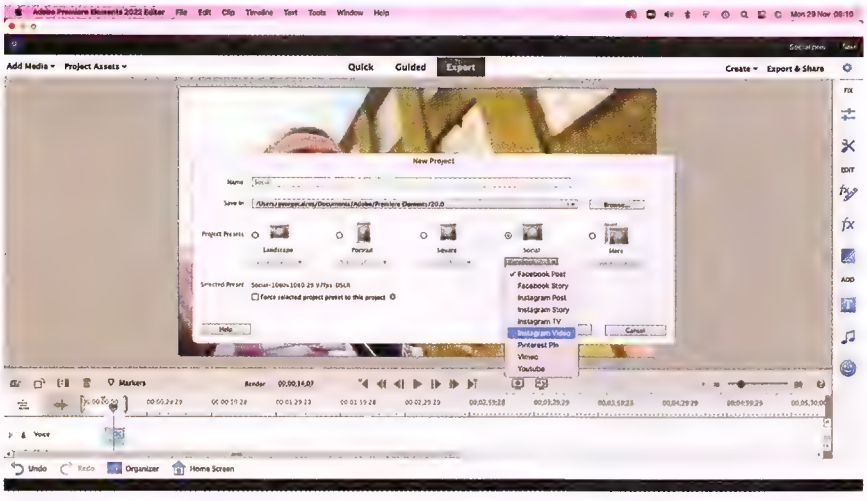
Moving on

After trying the tricks and techniques introduced by the Guided Edits, you'll become more confident in exploring the Expert workspace. This workspace looks similar to other non-linear video editing apps with a bin full of unedited project assets at the left, a timeline along the bottom and the edited programme displayed in the viewer. Extra tools such as filter effects can be summoned by clicking icons on the right. Unlike the Quick workspace, here you can add video and audio content to multiple tracks to combine clips in more creative ways.

You may have shot some footage while holding your phone vertically, while other clips may have been recorded in the more traditional horizontal landscape orientation. Some social media sites will automatically crop your clips to suit their preferred aspect ratios so key content could be lost at the edges of the frame. Premiere Elements 2022 is designed to set your project's timeline to suit a range of aspect ratios (such as a vertical 9:16 or a square 1:1). If you have a mix of vertical and horizontal oriented clips then the timeline's new Auto Reframe button will crop a clip intelligently to preserve key content while losing black bars at the edges.

Unlike Apple's iMovie and Final Cut Pro, Premiere Elements 2022 doesn't recognise or read clips captured using the iPhone 13's new Cinematic mode. However, if you share Cinematic clips from your iPhone to your Mac via AirDrop then the clips will be compatible as long as the All Photos Data option is toggled off.

Adobe Premiere Elements 2022 focus on using animated overlays to create eye-catching social media content helps it keep pace with competing non-linear apps such as CyberLink PowerDirector 19. If you're already using Photoshop Elements 2022, Premiere Elements will slot smoothly into your organising, editing, and sharing workflow. You can download a trial version of Premiere Elements 2022 for 30 days' free and full access to the app.

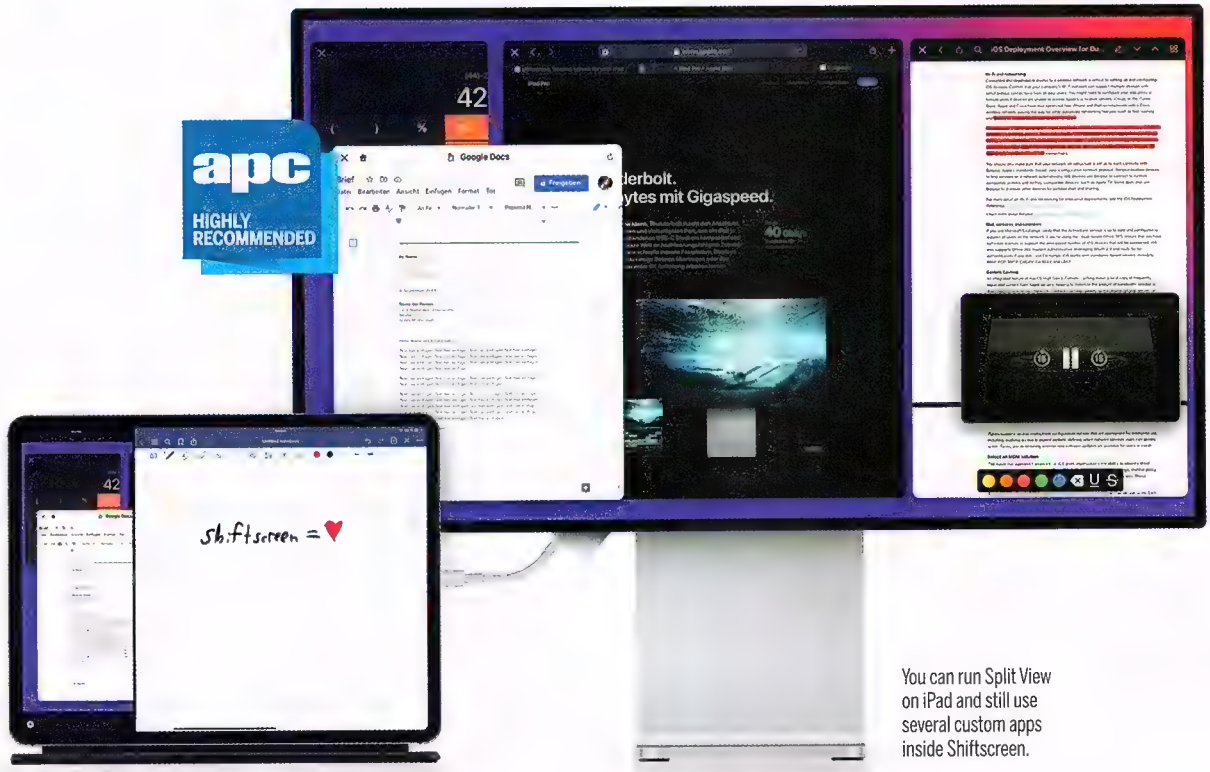


You can set up projects to suit the sizes required by social media site. The new Auto Reframe tool helps crop clips to lose black bars at the sides.

Premiere Elements 2022 helps novices hit the ground running as it guides them from simple to sophisticated editing techniques.

George Cairns

★★★☆☆



You can run Split View on iPad and still use several custom apps inside Shiftscreen.

MAC STORE & OTHER MAC APPS | iOS OR iPADOS 14 OR LATER | $12.99 | shiftscreen.app

Shiftscreen 4X

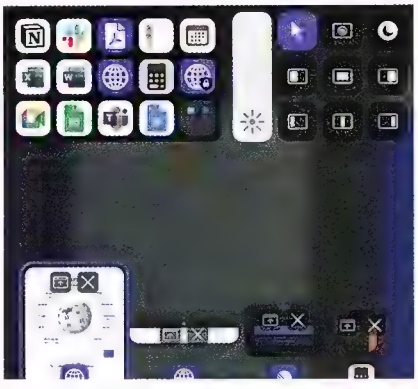
Bring multi-monitor support to iOS.

Apple likes to tout the iPad as being capable of replacing a computer but in some areas it falls short. One example is using external monitors. Although you can physically connect to a second screen with a cable or wirelessly using AirPlay, iPadOS and iOS limit you to simply mirroring what's on the device's screen. And even worse, you'll often get mismatched aspect ratios, resulting in wasted empty space on the external screen.

Shiftscreen is an attempt to get around this limitation until Apple decides to fix the issue, which may never happen. It's an inexpensive app that lets you create virtual desktops hosting their own custom apps for various tasks. It can't run other apps installed on your device, so no games, weather apps, video editing, or anything like that. This does make it somewhat limited in that it doesn't achieve 'true' second screen support, but this is Apple's limitation and there's not a lot developers can do about it at present.

Launch the app and you are prompted to connect to a second monitor, either via a cable or over AirPlay, to an Apple TV say. It can also use the display of any Mac running macOS Catalina or later. The app is smart enough to detect the screen size of the external monitor and fill it completely, even when the iOS device is in portrait orientation. It has a launchpad from where you can open its special apps and up to six windows can coexist at once.

There's a browser through which quite a few apps operate, providing access to web-based services like Google's productivity apps and Google Meet video conferencing. There's also a PDF viewer, a calculator and shortcuts to Slack and Notion. At the time of review, the developer was working on adding support for MS Excel and Word as well as the Reminders and Calendar apps from iOS.



Various web-based services are provided as apps.

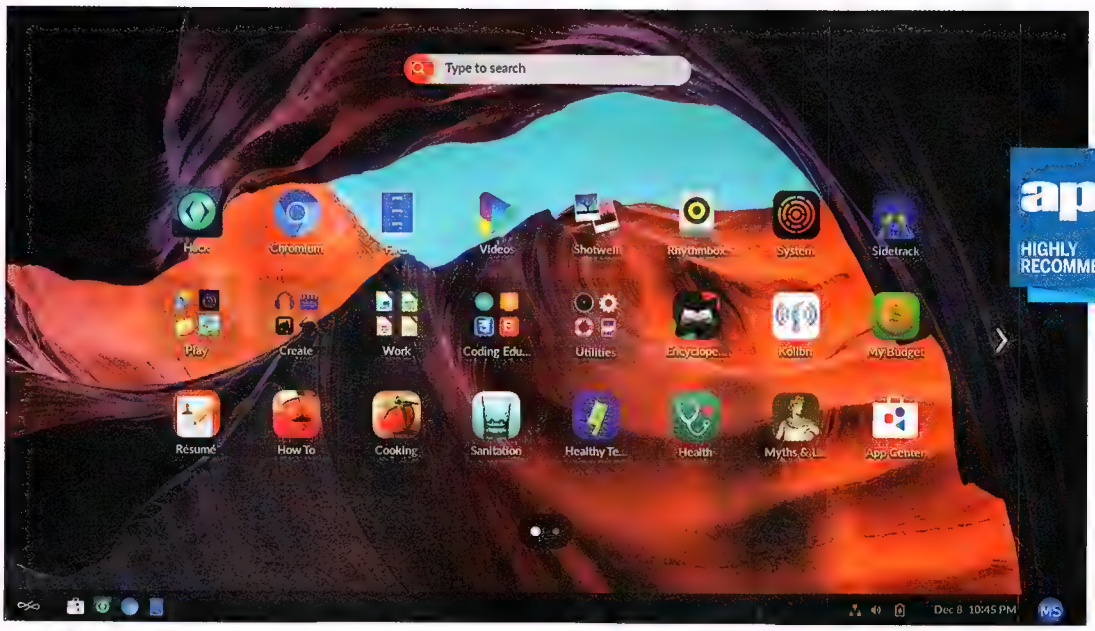
App windows can be resized and arranged by dragging and the main app also supports mouse, keyboard, and trackpad input modes – any combination of which do make using it smoother. If you enter Split View on the iPad you can use a 'regular' app alongside Shiftscreen on the iPad's screen. When you do, Shiftscreen's window shrinks but there's a zoom mode that lets you navigate efficiently, and the external screen remains at its full size. Helpfully, you can set up multiple virtual desktops with custom app windows already loaded, which saves time.

Shiftscreen's apps are basic but will surely expand over time. That said, if your iPad is perhaps in a dock, with a keyboard and mouse connected for optimum workflow, it's an innovative if imperfect way to open up the extra real estate that an external monitor provides.

Shiftscreen offers a clever, if limited way to open up iOS and iPadOS.

Hollin Jones

★★★★☆



apc HIGHLY RECOMMENDED

Experienced users can use the Endless OS image builder tool to create a customised distro.

Linux | www.endlessos.com

Endless OS 4.0

Five minutes with the latest version of this distro and Mayank Sharma is reminded of the old adage: "The whole is greater than the sum of its parts."

Endless OS is a unique learning-oriented distro that helps users stay productive with their computers even when they're not online. Version 4.0 introduces a plethora of changes, both in the background and on the desktop.

For starters, the developers have dropped building every single package on their own, and instead borrow a majority of them from Debian. There are still about 120 packages they build themselves, since they need to customise them for their purpose, but the change in approach has helped cut down the development time significantly.

Furthermore, Endless OS 4 is the first long-term support (LTS) release of the distro, which the developers plan to support for a number of years even after Endless OS 5 is released. Having an LTS release will complement the distro's purpose of making tech more accessible by elongating the life of existing PCs.

One of the unique aspects of the distro is its desktop environment, dubbed the EOS Shell, which is a heavily modified Gnome 3 desktop. In a departure from the traditional desktop metaphor, EOS Shell doesn't include an application launcher, and instead peppers application icons and groups on the desktop itself. Clickable arrows enable you to switch between pages of applications, since the earlier arrangement prevented many users from discovering the full distro's collection of programs.

Another difference is the shift to the open source Chromium browser, which now comes pre-installed with the distro, instead of the proprietary Chrome, which was fetched automatically once Endless OS had access to the internet, and caused some usability gotchas.

Talking of usability, one of the interesting aspects of the distro is its parental control functionality. In order to make it more usable and extend its area of influence, the developers have decided to pack in Flatpak versions of several programs, including Rhythmbox and Cheese. Thanks to the change, these applications can now be disabled or removed through parental controls.

In fact, Endless OS's developers are such big fans of Flatpaks that they've tweaked the Gnome Software tool to only fetch Flatpaks from the Flathub repository. However, while you can't tweak the repositories by modifying the settings of the graphical package management tool, you can use the apt-get package manager from the command-line to install applications from the Debian 11 repositories.

Endless OS is available in two flavours. In addition to the 17.1GB Full edition, there is also a Basic release that weighs in at a far more manageable 3.3GB. In addition to the desktop images, the distro also puts out ARM64 images for ARM-based single-board computers like the Raspberry Pi 4. Unlike previous releases, which only worked on the 2GB and 4GB variants, Endless OS 4 supports the 8GB variant as well.

Endless OS uses a custom installer that's designed to take over the entire disk. You don't even get to choose a custom layout or a partitioning scheme, which might not be appealing to advanced campaigners, but will simplify the process for the distro's primary audience.

Every aspect of the distro, from its reimagined desktop environment, to its collection of programs and educational material, to its locked-down approach that delivers a pre-cooked environment, is done after keeping in mind the sensibilities of Endless OS' intended users, and their shortage-fuelled use-cases, such as lack of internet or lack of technical dexterity.

And they've done a cracking job of it. Endless OS 4 is loaded to the brim, yet instead of bursting at the seams, it goes about its business rather gracefully.

The comprehensive, well-designed, multi-lingual, multi-platform learning distro delivers on all its promises.

★★★★☆

JUST HOW DO YOU BECOME A PC MODDER?

KRIS BUTTERILL GIVES US HIS PERSONAL TAKE ON HOW TO GET STARTED IN PC MODDING.

PC modding frequently leads the way in our computing hobby. It sits among the giants that make this community so great and continues to push through advancements and product tweaks into the industry itself. Vertical GPU mounts? Modders did that first. ITX liquid-cooled cases? Modders did it. Liquid-cooling in general? Modders did it (with household plumbing parts, would you believe?).

But there's more to it than that. It's an intricate art form, a way of showing off your personality and building something unique to you. The hardware might be obsolete in a few years from now, but ask any of those modders what build they're most proud of, and it'll bring back a flood of memories from yesteryear, now outdated by the superior chips of today.

For the extreme enthusiast, a PC is akin to a custom car. Unique, special, filled with memories of good times and more. Since its conception, the modding scene has grown into a behemoth compared to what it once was, filled with competitions and extreme professionals, and all sorts of amateur enthusiasts.

It pits the best ideas against one another, with a ton of free hardware on the side, sponsorship, travel, and more.

So then, you want to start modding, going to events, showing off your latest builds on global social media channels, and work with the best hardware manufacturers in the world? Well, so did I back in 2019, and I didn't have a clue where to start.

My interest in building computers was with me way before I even thought about pursuing it in a more formal fashion. I mean, there's no training course you can enroll in and no books to guide you. It's been a different journey for every single person who has ever become a relatively well-known modder. It takes a lot of hard work and, at some point, luck may step in and help you along the way as well.

Today though, let's start with the basics, go over how to get started and hopefully, by the end of reading this, you might have a clearer idea of how you can get involved in the modding scene too.

© André Pattenden Photography (andrepattenden.com). instagram.com/andrepattenden/

Warren Faidi

Getting to know yourself

My life is average; I'm married and have two children, a mortgage, and all the responsibilities that come with everyday life. There are bills to pay every month, activities and days out to go on with the family, and the small matter of working 48 hours a week. I've always been handy, capable, inquisitive and functional, in terms of having a hands-on approach to learning. It's how I do things, take something apart, put it back together, rinse and repeat. It's why I started out as a mechanic for Volvo, moving on to Audi before following in the family footsteps and joining the Fire Service at 23.

What I am getting at here is there's already a lot of commitment in life, commitments that come first, before even starting to look at taking on a modding career. The first thing you need to know is that modding takes three things; time, commitment, and perseverance.

Once you are prepared to give all those three things in equal measure, it's time to have a chat with yourself and be honest. Are you competent in building a standard DIY PC? I'm talking about simply fitting components to a case, adding an AIO and the mother of all tasks, the number one, and most asked question I ever see, where do these wires go? It's fine wanting to become a modder, and we all have to start somewhere, but if at this first step you are unsure, this is where you need to start reading, following tutorials, and getting hands-on, even with the most basic projects to learn the trade.

It's all about building from a foundation, being comfortable and competent. At this stage, some might even find that it's more involved than they first expected, the time commitment can't be met, and so on. It's better to know now that it's not for you, rather than six months down the line when you could potentially have invested both precious time and finances into the field. If this isn't for you, then that's fine, but if the above doesn't faze you then read on.

We'll assume you can build a standard PC, install Windows and download the latest drivers. So, now it's time to get involved.

From here, things start to get more complicated. Now you need to look at why you want to venture into the modding scene. Is it because you enjoy building PCs, want to show off your work to others, have some great ideas and a creative mind? There are a thousand reasons I can think of, but probably another thousand credible ones too. Once you have a reason, you need a plan, a direction, a road map, or whatever you want to call it.

A 3D printer could be the most useful item in your tool kit, but don't forget to get a Dremel too.

Think of this stage like a job interview; ask yourself why you want to do this, and where you see yourself in five years' time. For some, it simply is the love of building PCs, others use it as a stepping stone to bigger and better things. Some may have a background in one particular specialist area, be it overclocking, great at taking photos, have access to all the machinery needed to create custom distro plates or props. Think about what you are good at, and what you can bring to the scene, and use that to your advantage.

Being Prepared

What do you actually need to start producing epic mods? This can vary from a couple of rattle cans to a vinyl cutter, tools, consumables, and, of course, hardware. There is little chance of being sponsored without a history, so you need to be clear in your mind that things won't fall into place straight away.

Depending on your background, you might already have a nice complement of tools at your disposal, use this to your advantage. A modder needs tools, it doesn't have to be a workshop full of the latest machinery, and modding can be as simple as having a jigsaw and a file to hand. It's better to start with hand tools, refine your craft to a point and then, when things start getting too complex or require such precision that it can no longer be achievable by hand, expand your equipment gradually.

In terms of more advanced tools, here's a couple of suggestions that might be worth considering:

Dremel A modder's favorite that has so many uses. A beginner set is cheap and perfect for those delicate operations, and also helps to get into small spaces within a case for mods, cutting panels, trimming edges, and much more. Don't leave home without one.

Vinyl Cutter Relatively inexpensive and can transform even the blandest case into something special. Most vinyl cutters can be found relatively cheaply with small ongoing costs for consumables.

Vinyl cutters can be used for a number of things, adding graphics and small details, but they can also cut stencils for using to add your airbrush designs to cases and parts. Stencils are also needed for glass etching, another way of adding a custom touch with relatively little consumable cost.

3D printers Probably the best thing in my tool kit, and one of the most fun things I have ever used. I did have a CNC, but the 3D printer can do so much more. In terms of cost, a 3D Printer is also more accessible.

Some of my recent projects needed adapters for mounting Alphacool reservoirs to a case, and I also had four Corsair Commander Pros to fit too; cue some measurements, Sketch Up, and three hours later, I had all the parts I needed. It's great for prototyping, and I'm finding that I am using it for things even I didn't think it would be useful for. Its best quality, though? It saves precious time so that you can concentrate on other issues.

There are some epic case mods using 3D printed parts, and even fully 3D printed cases out there, the only limit is

© Dremel.com

Modding is part trial-and-error. When it works, it just works.

your imagination. Down the line, if things go well, this should probably be high on your shopping list.

Inspiration

If it's just another Lian Li O11 Dynamic build with ten fans and an AIO, then I have some news for you, there are thousands of people doing that already. That's where you need to read between the lines, find that extra something that at first glance makes your work stand out from every other system.

Looking at what is already out there is a great point of research, one that sometimes gets overlooked. Trawl through the various forums and social media to see what the current trend is (**pcpartpicker.com** is a great place to start, along with **builds.gg**), what's emerging, and what no one else is doing. If people are not building what you have in mind, that could be for a couple of reasons; it isn't viable and the end result will be poor, or it could be that no one has thought about doing it yet. That's where you take the limelight and potentially set the next big trend.

For example, if you are a carpenter by trade, your experience working with wood can lead to concepts and ideas that someone without such knowledge will overlook. Metalworkers might view industrial themes and ideas for builds more favorably because it's an area they know in-depth. Whatever your passion, whether it's cars, sports, films, games, brands, there's something for everyone.

Transfer elements over to PC building and do something new, original, maybe exotic. There is inspiration all around us, every day, in every walk of life. Don't be scared to try something new. At first, it might feel absurd, but the reward generally outweighs the risk of trying something new. If you have the hardware to hand, especially when it comes to water cooling, then why not use two reservoirs, three, or even four? From a performance aspect, there's a diminishing return, naturally, but aesthetically, depending on the plan, it can make or break a build.

I remember placing a small Alphacool reservoir mid loop, above a GPU and thinking, nope, but once the loop filled up, it looked great, and so was the feedback. The question I was asked most was 'Why?' My answer was why not? It's different, it fits the boldness of the build and it looked fantastic.

Building systems

This right here is what it's all about. Modding PCs doesn't have to use the latest and greatest parts. Depending on your circumstances, you can start with older hardware. This makes it less expensive should you make a mistake and there's less pressure too. Be creative, even if it means cutting up a case, it's not the end of the world if it doesn't turn out as expected. Sometimes the most effective mods involve the simplest of ideas.

There's an assumption that modders have access to all the hardware they could ever dream of, and while that's true for a small minority, for most it's a little more limited. I've built a number of totally different-looking systems that recycle the same hardware, essentially building one system and then stripping it down as soon as the project has been completed, ready for the next one.

Start small, if you already have a PC, use this as your first project. Look at what you have and what potential it has in terms of modifications. Some cases are so modder-friendly that some simple alterations immediately make them stand out. The local second hand market is rife with slightly older parts, cases, fans and a whole load of components can be found for little to no outlay on places such as eBay. Some subtle upgrades and even investing in extra hardware will help you build up a stock of parts. One of the biggest issues I had at the beginning, and still have now, is trying to keep a system dedicated for my own use, for office tasks, editing photos, rendering videos, and everything else that goes with modding.

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All builds start with a plan and this can be based on a number of factors, if there is a new case coming out that fits perfectly with a theme, that will to some extent dictate the hardware. If there's an ATX motherboard you want to use, that will be the total opposite, dictating what cases are available. Scratch builds, desk builds, monster towers, they all start with a plan, maybe even a few sketches and then, a whole load of planning. What matters most, more than anything, is your attention to detail. There are so many aspects to building a PC, but the two areas that tend to be scrutinised more than anything else are custom hard-line loops and custom cables.

Custom hard-line loops take things that extra step, away from a bolt-on AIO and where things can truly start to get creative. As you build more and more systems, you get much more confident with the process and start to see things that you wouldn't normally. Bulkhead fittings to hide pumps out of sight, interesting tube runs, dual loops, coils, there are so many creative options that bending hard-line tubes brings. I won't lie, it takes time to perfect, something I am still doing. Be prepared to bend four runs to get the perfect one. There's a lot of waste to begin with, but experience will soon play its part as you get better.

Making custom cables is another aspect that, with relatively little cost, can make a build pop. Time and patience are key to producing either extensions or full replacement kits for your builds. Personally, I hate making my own cable sets so I would sooner support someone in the community who does this on the side and produces results far better than I can. The thing is, not one single modder can do everything perfectly, everyone has a weakness, and realising your own will help you. If it's not making cables, it will be something else, let the community help you, it helps them too, and by outsourcing small elements you can also help to build up relationships as well, which is vital in the industry.

Use your photography skills to create a new look.

Being social

Once you have a build under your belt it's time to share it with the world. Setting up on social media is one of the first steps to being noticed by the community and companies. If you decide to work under a modding name, then choose wisely from the beginning. You don't want to be changing things three years down the line because you wished you had picked something different. People get to know the names in the community, it builds familiarity

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When showing off hardware, you can tag the manufacturer.

and a following will start to form naturally.

There are a number of ways to start with social media, including Facebook, Instagram, Twitter, YouTube, Discord, forums such as Toms Hardware Guide, and many manufacturers have their own dedicated forums. Setting up a website can help too, I use one to log the projects, features, and events I have been involved in, that way it can act as an online CV for anyone curious about your work.

If you are comfortable or have experience in front of the camera, then use that to your advantage and make YouTube your primary platform, if you have great camera skills and can make the final shots of a system really pop, then maybe Instagram and a Facebook page would be more suitable. Project logs can be very involved and in-depth, but whatever platform you choose, it's all about telling a story.

Regular posting and planning will help. You don't want to be posting once a month, it needs to be as regular as you can. If you are using a case from say, Cooler Master, for example, then let them know, tag the companies whose parts you will be using, and let them start to see what you are building.

Remember when I talked about custom cables and building relationships? Well, this is where it starts to all tie in together and help you along the way. If you post a picture and someone has made the cables for you, tag them, they will see it and hopefully repost it, tagging you in the process. You potentially just doubled your audience in a simple tag, they want to show off their work too so it's a great way to do things.

Many forums run monthly competitions, **builds.gg** and Bit-Tech to name just a couple, get those project logs going, you will gain valuable experience with each one and enter Mod of the Month events if you can. It doesn't matter if you place last, it's part of the process to learn from and build upon. I've built systems that I thought would place high but didn't. For whatever reason, people have their own preferences on what looks awesome and other systems in the competition, at that particular time will dictate, to some extent, how well your build is rated.

Don't let it get you down though, it's not because it's a bad build, it's just that other systems might have something that people favor more.

Showing your work to the world in person is a great way to not only get people interested in what you are doing

A build for Asus to celebrate Ghostbusters at EGX 2019.

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but may also bring a number of other perks. If it's a local meet or event, take your build, take some photos, tag the event organisers on social media, let visitors take pictures of it, ask them to share it on social media, even make a small placard with your details on it so people can find you.

Get involved and answer the questions they might ask, why did you do this, how did you do that. There are some huge expos and events around the world where your work can be shown, the plus side too is that at the bigger events, there are reps from many of the manufacturers. Play to their strengths, build using their hardware, and make sure they see your work in person.

Making contact / sponsorships

There comes a point when you have a number of builds under your belt, you have entered the forum events, posted to social media, and done as much as you can. Now do it some more. Spend another year refining everything you have learned, Three years in and I'm still learning.

At some point though, you will feel the need to reach out. You have started building that portfolio and following. You have used all the components you have and recycled them time and time again for another build. Sometimes it feels like you are getting nowhere and you need that next kick. Find out what's missing, do it some more and then do it again. Now, you either need to invest in more hardware or see if anyone is willing to help.

Straight off, the big hardware players might not be interested; you're unlikely to have a CPU, motherboard, and graphics card sent to your door unless you are really lucky or time it just right. Start smaller, the less expensive the items, the less risk there is to the company looking to sponsor. It's time to start making connections, finding the right people, and putting your ideas over to them. Build a system, see what you are missing, and maybe start with case fans, power supplies, air coolers, and AIOs. These are components you can easily show off, giving a sponsor a return on its investment

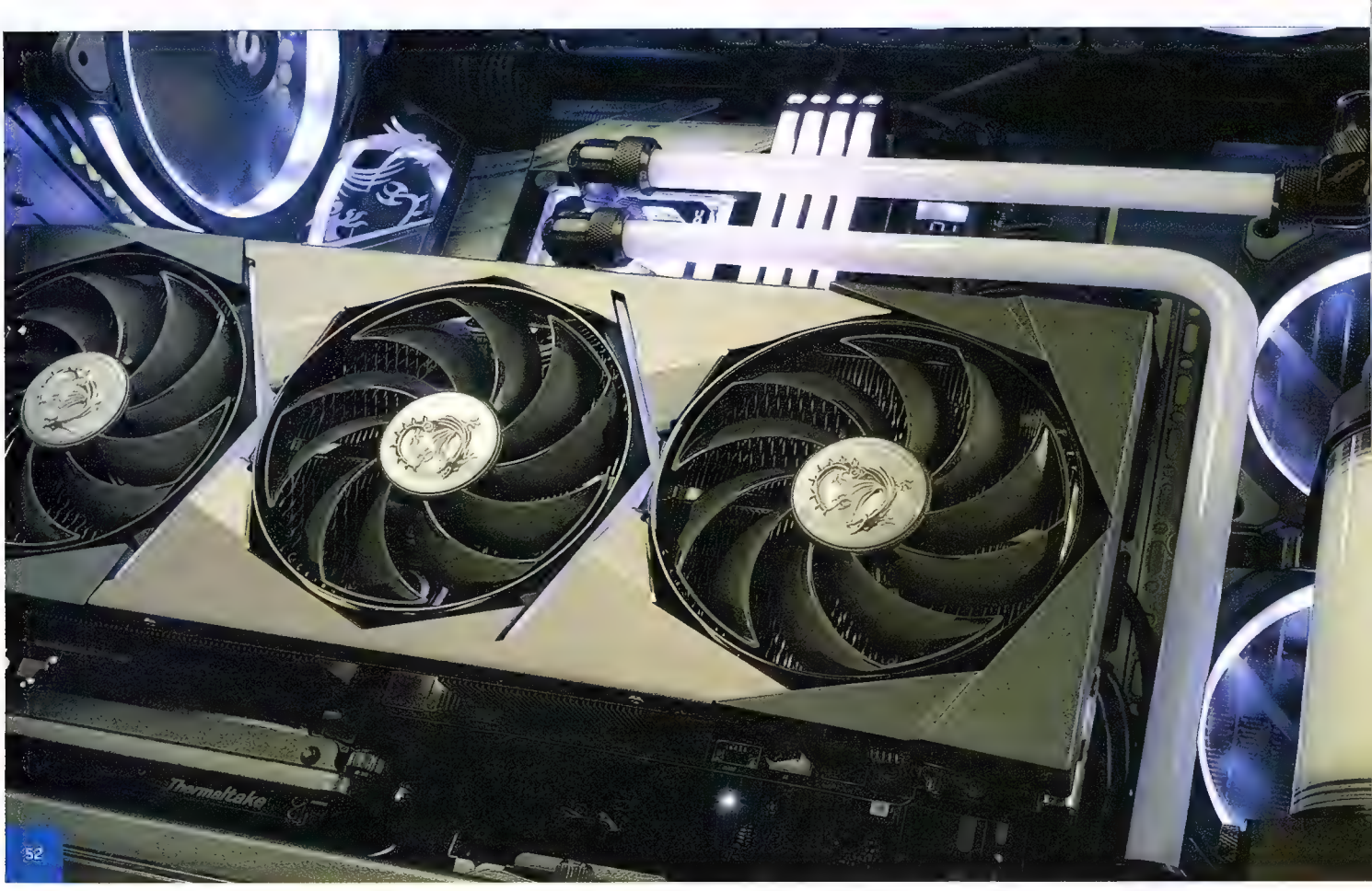
Now, finding the right people to contact can be a challenge in itself. Research their websites and social media, if you can't find what you are looking for, it's worth messaging the social media accounts of the people you want to work with, ask them politely if there's an email for sponsorships for your region. Some might reply, some won't. Don't pester them; follow the leads you have at this time. Once you have a contact, it's time to write them an email. Can I have free stuff, please? No, never write that. Even as a relative newbie, I get this now. It's strange, I'm not a manufacturer so it shows just how little research that some people are doing.

In your email, introduce yourself, attach images of your past work, maybe tell them you won a Mod of the Month, or show them how many views you had. Show them what you are working on and how their support will help set it apart. It's a two-way street, so show how you can provide exposure for them. Make sure you outline exactly what you intend to do so there's no doubt what they are getting in return. Proofread it once, then again, and when ready, hit that send button.

Now, wait. Give it time for the email to reach the intended recipient, allow two weeks, and then, if you have to, follow it up with a courtesy email. Some will have ignored the first, the second will most likely prompt a response of "Thanks for your email, sadly at this time we are not taking on new sponsorship requests". If they are interested, a response will usually be fairly timely. Respond gratefully, addressing any queries honestly and clearly. When you land that first sponsor, it's a great feeling, but if you keep up the hard work, it's the start of things to come.

Delivering on what you promise

Modding can be hard and, at times, the pressure is relentless. So you put the idea to the manufacturer, they loved it and want to support the build. The free stuff is on its way and then, for



whatever reason, life gets in the way, you lose heart in the project. Whatever the issue is, you have to deliver. Remember these companies get literally thousands of emails a day asking the same questions and proposing the same things. They picked you, put their faith in your abilities, and now the responsibility lies on your shoulders to deliver.

Getting that first sponsor is as important as the sixth, tenth, or however many it ends up being, so build that relationship and keep it up. They are investing in you, both financially through the costs to them for the parts and shipping and also on a moral footing.

If there's a delay, an unseen issue, let them know as soon as possible what the issue is, how it can be rectified and when it will be resolved. Communication is key and the more you deliver on what you promise, the more chance there is that the relationship will continue. Why not go one step further and support them as much as they are supporting you? A $150 case from a manufacturer worth millions might not seem like a big deal, but multiply that across all the other avenues manufacturers explore, modders, tech journo reviews, events, giveaways, it all adds up, more often, to more than you might think in terms of outlay.

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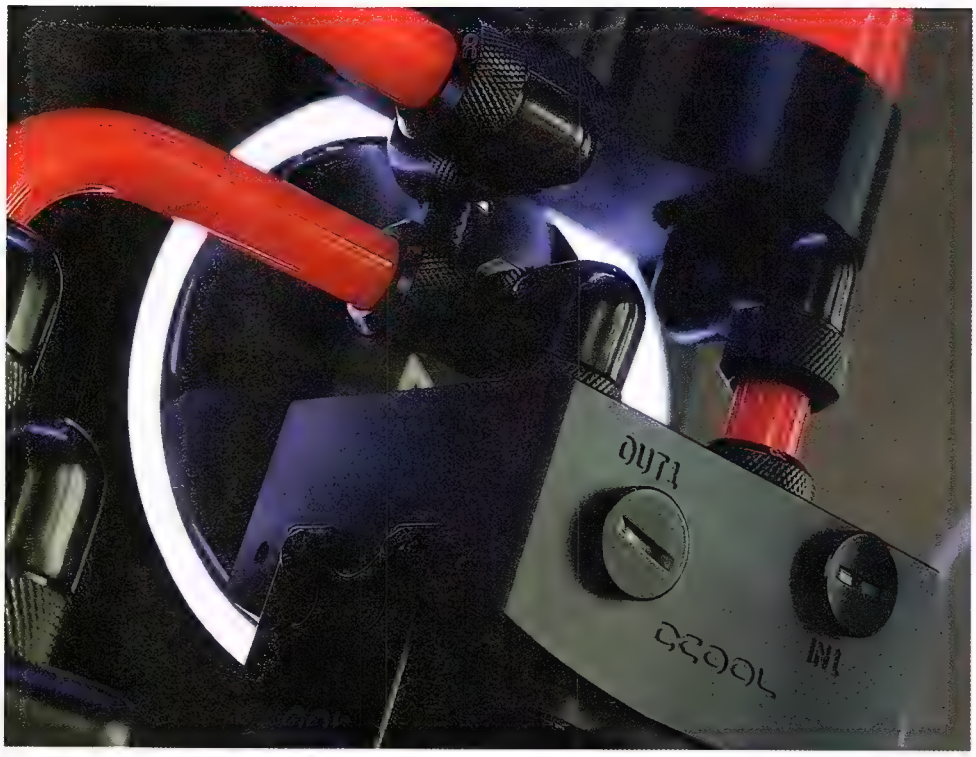
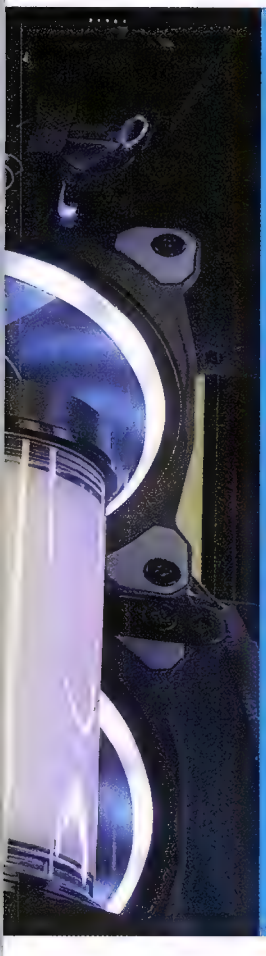


Start with components that you can easily show off.

Good luck

So there you have it, how to start in the world of being a modder. While this isn't all, it's enough to get you on the right track, and to some extent, it's how I started too. I've had my share of luck, but that was backed up by a lot of hard work and it's because of that I'm writing this article. Modding has taken me on a great journey so far and it has opened up some fantastic opportunities. I never expected to be writing for a magazine, let alone giving advice on modding.

I have one final piece of advice. Enjoy it. Once the fun dissipates and it becomes a chore, it's time for a break, no matter how good you are or how many builds you have lined up. Come back fresh-faced when the time is right, your work will reflect the results of taking a breather. So now, go my little budding builders, cut up that case, mount that radiator where you want to, go with the rainbow RGB, hell, go with no RGB if you like! It's your build, it's your rules. Don't follow trends, set new ones, and remember, if anyone asks "Why?" Simply reply, "Because I can". ■



COMMISSIONS

For some, this is the pinnacle of modding. That email drops in from a global player, the one company you love more than any other, and they want you to build them a PC.

They have seen your work, your posts, and your sponsored builds, and now want you to create something special. Personally, I've been there, and it was only at this point that I finally felt I had made it, and could justify the time commitment and perseverance. Heard that bit before? It makes more sense now than it did at the beginning, right?

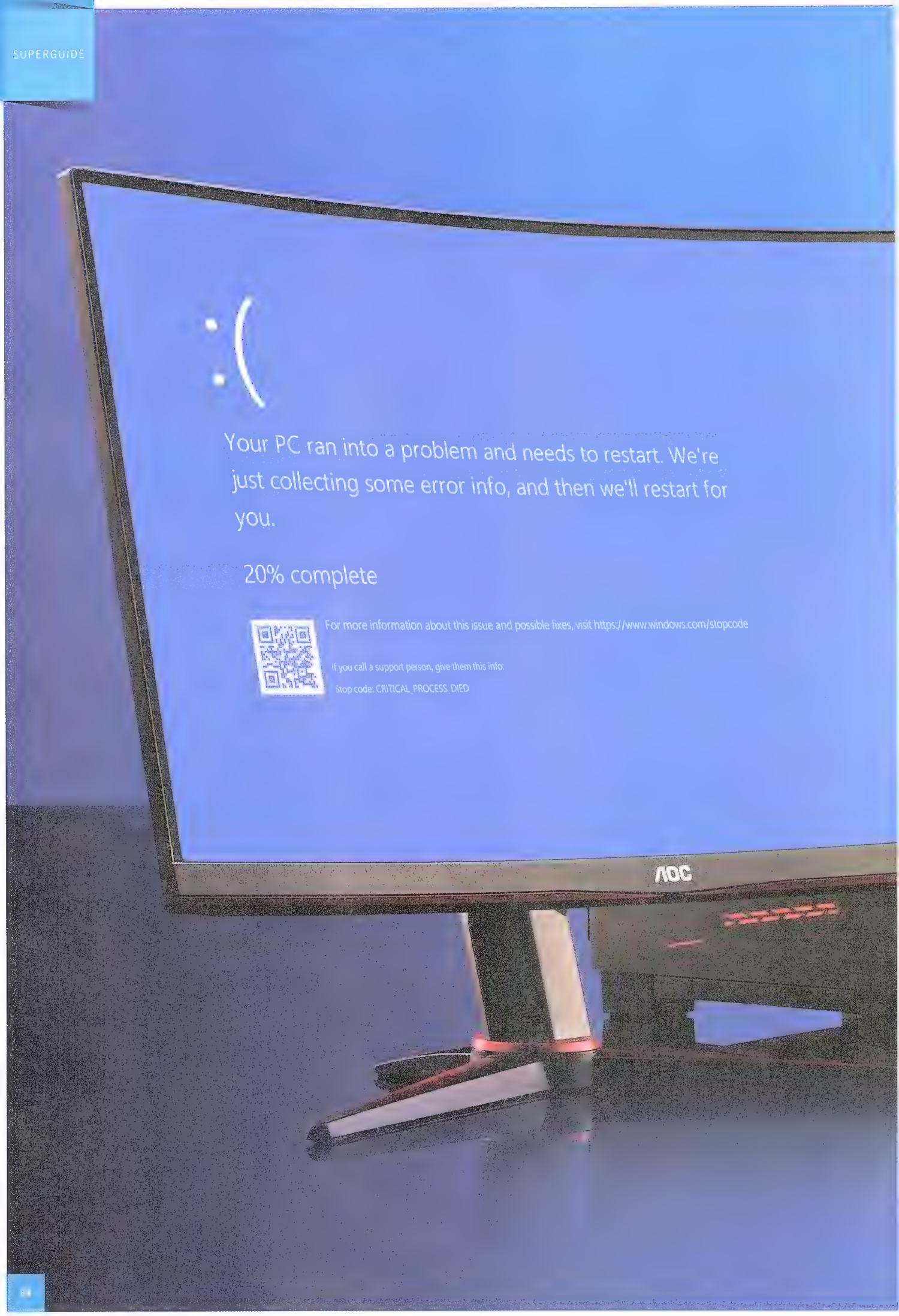
I also asked, where do you want to be in five years' time? This is what I wanted to achieve and well, I made this in fewer than three, but mileage does vary and luck plays a massive part. I had a request to build a system for MSI. It was getting a build to a well-known Minecraft influencer and wanted me to build them something in exchange for some hardware. I could use for my own builds.

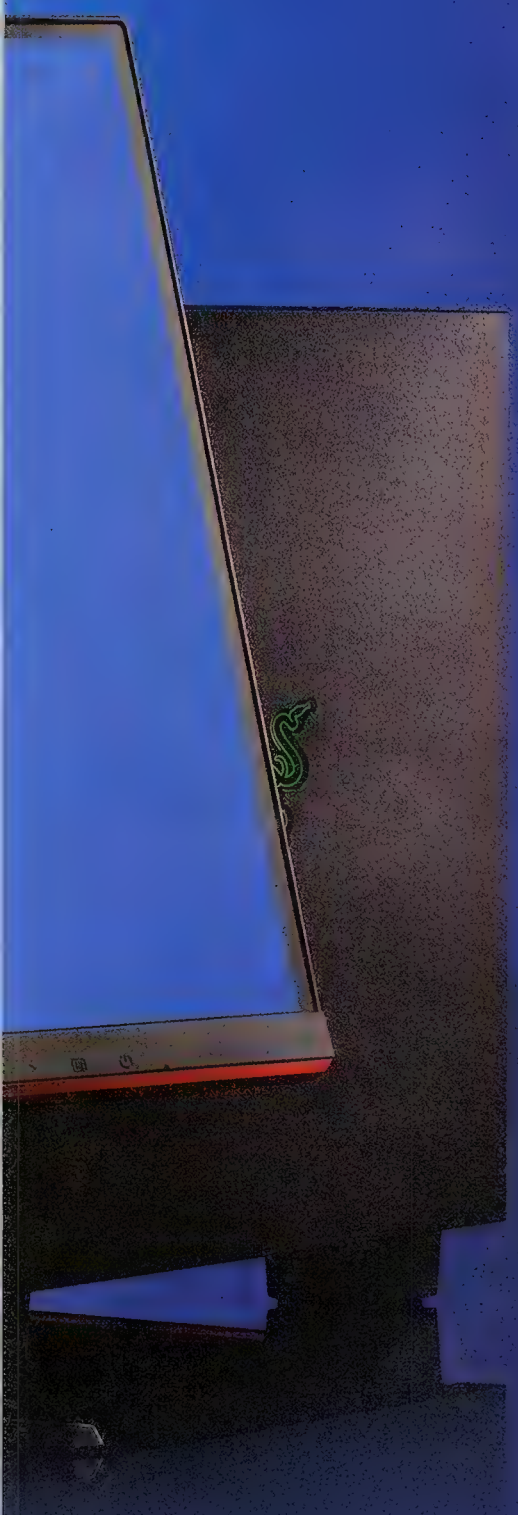
The client in question had over 8 million YouTube subscribers, so the pressure was on. Looking ahead, I could see that this build and potential exposure would help me again for the future, especially with the hardware they wanted to send out.

Roll on six months and there was an email from Intel. This time wanting to pay me to build a system! Intel had seen the build I did for the influencer two days after that I got another email. Asus wanted me to build a system too. All of a sudden, I was in demand.

For the next few months, all my personal work went on hold. I had to explain to my sponsors and again communication is key. These commissions were a priority, but that didn't mean I could negate my other responsibilities.

Luckily, they were pleased for me. It showed that the faith they put in me was paying off in the fact that these other brands now wanted to work with me, based on what they had seen from my work with sponsors. It all ties together, eventually, and it's all worthwhile.


:(
Your PC ran into a problem and needs to restart. We're just collecting some error info, and then we'll restart for you.
20% complete
For more information about this issue and possible fixes, visit https://www.windows.com/stopcode
If you call a support person, give them this info:
Stop code: CRITICAL_PROCESS_DIED
AOC



SAVE YOUR SYSTEM!

DISCOVER HOW TO FIX YOUR WINDOWS PROBLEMS LARGE AND SMALL WITH THE HELP OF NICK PEERS.

Benjamin Franklin famously said that an ounce of preparation is worth a pound of care, but when it comes to troubleshooting Windows problems there's only so much you can set up in advance. Even with the best backup regimen in the world, you can't always inoculate yourself against a Windows error, crash, or complete meltdown.

Don't worry though, because armed with a few tips and techniques, you'll be well-equipped to deal with the worst that Windows can throw at you. We'll start with the most catastrophic circumstances – a Windows installation that refuses to boot successfully to the desktop. You'll learn how to combine Windows' own troubleshooting tools with a powerful (and free!) third-party rescue disc to maximise your chances of fixing the problem. And if you can't get Windows to boot again, we'll reveal how to recover important files from the disk before performing a full reinstall.

Even when you can boot into Windows successfully, the problems don't stop there. We'll take you through some useful troubleshooting techniques covering a range of issues, from Windows Update to problems with USB peripherals and issues with non-responsive or freezing applications. And to help you tackle these problems with the minimum of fuss, we'll namecheck some free tools designed to diagnose and fix problems on your behalf.

If you can't find the solution to your specific problem from our advice, no worries. We reveal the key tools and techniques you can employ to diagnose and fix problems, and information to gather (and where to find it) to help you hunt for a fix online. If all else fails, we'll also show you how to perform a 'repair' installation that will attempt to refresh Windows without wiping any programs, settings, or data, helping you to fix more deep-seated problems without reaching for the nuclear button.

Whether your Windows-related issue is a minor irritant or of major concern, you'll discover how to take back control of your PC and potentially save your system from a needless full-blown reinstall.

Windows problems come in all shapes and sizes, so let's start by taking a look at the biggest problem likely to come your way: boot failure. If you've not yet created any rescue media, you'll be forced to rely on Windows' own troubleshooting tools, so let's see what's available.

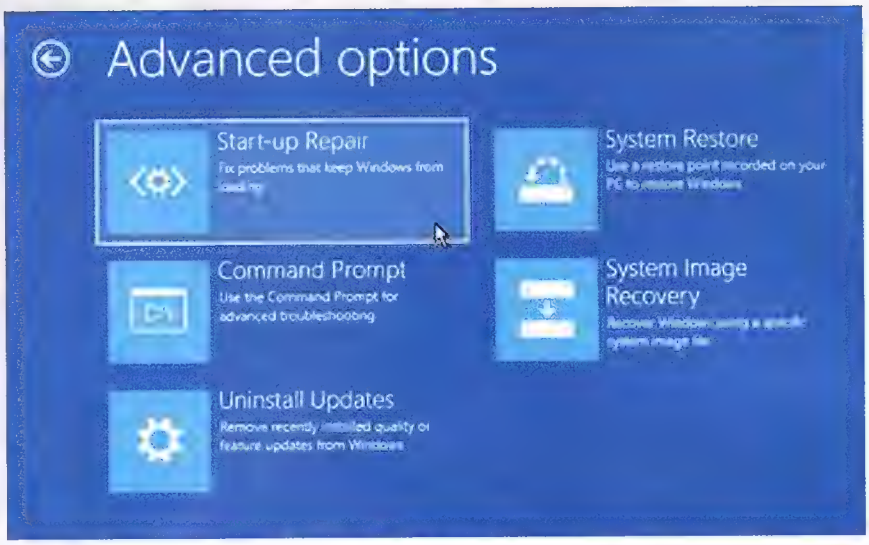
First, we're going to assume your PC has passed all basic hardware checks on first boot, your UEFI or BIOS has been able to detect your Windows boot drive and handed control to it to start loading Windows. If no bootable operating system has been found, it's possible the drive has failed. You'll need to boot to a recovery environment to see if the drive is still physically visible – Lazesoft Recovery Suite is a good tool for the job, and we'll explain how to use it later on.

Assuming the drive is detected, and you're able to see evidence that Windows has started to load before running into problems, you should find Windows' own automatic startup repair tool has sprung into action after a failed boot operation. It may run several times, rebooting between each attempt, so sit back and be patient. If you're lucky, Windows will now load; if you aren't, it should eventually bring up the advanced start-up tool with the all-important Troubleshoot button under 'Choose an option'.

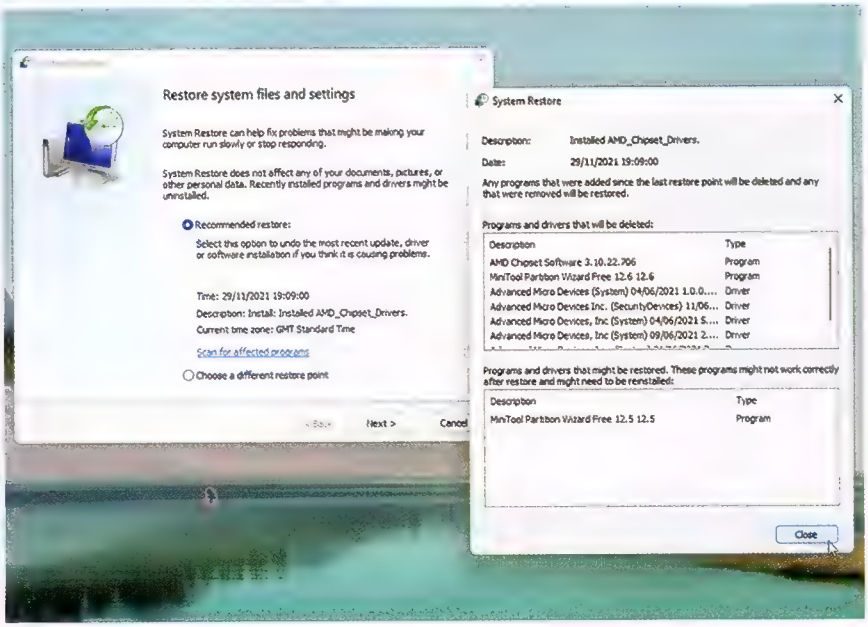
The next step depends on your circumstances. For example, if you're unable to start Windows after installing a recent feature or quality update– in the case of Windows 10, the most recent major update is the 21H2 update – then try 'Uninstall Updates'. First, choose the type of update you want to remove, select Windows 10, and click the uninstall button.

Failing that, if System Restore hasn't been disabled, you may be able to roll your system back to a working state if you suspect a recent driver or program update or installation is to blame. Select it from the menu, then click Windows 10 or 11 and wait for it to load. A list of all available Restore points will be shown. Choose the latest one and click 'Scan for affected programs' to see what drivers and applications will be affected. Make a note, then click Next followed by Finish to roll your system back.

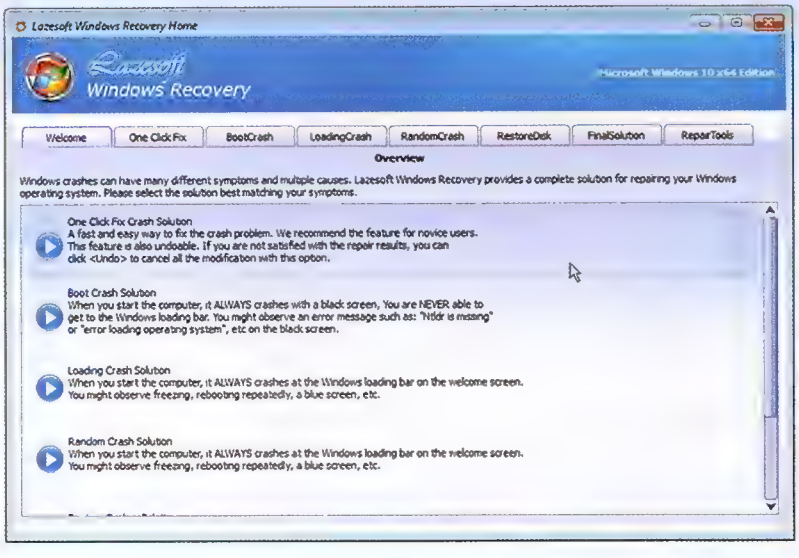
The final 'easy' option available from Windows' own troubleshooting tools relies on you continuing to use the Backup and Restore (Windows 7) tool to back up your hard drive via a system image. If so, you can restore the last backup taken using the System Image Recovery tool. It should detect your latest image and roll your PC back to a working state. If you've backed up using Macrium Reflect, use its rescue media to bring Windows back to the point your last backup was taken.



Windows offers a selection of limited recovery tools. This should be your first port of call.


Restore system files and settings
System Restore can help fix problems that might be making your computer run slowly or stop responding.
System Restore does not affect any of your documents, pictures, or other personal data. Recently installed programs and drivers might be uninstalled.
Recommended restore:
Select this option to undo the most recent update, driver or software installation if you think it is causing problems.
Time: 29/11/2021 19:09:00
Description: Install: Installed AMD_Chipset_Drivers.
Current time zone: GMT Standard Time
Scan for affected programs
Choose a different restore point
< Back
Next >
Cancel
System Restore
Description: Installed AMD_Chipset_Drivers.
Date: 29/11/2021 19:09:00
Any programs that were added since the last restore point will be deleted and any that were removed will be restored.
Programs and drivers that will be deleted:
Description
Type
AMD Chipset Software 3.10.22.706
Program
MiniTool Partition Wizard Free 12.6 12.6
Program
Advanced Micro Devices (System) 04/06/2021 1.0.0....
Driver
Advanced Micro Devices Inc. (SecurityDevices) 11/06...
Driver
Advanced Micro Devices, Inc (System) 04/06/2021 5....
Driver
Advanced Micro Devices, Inc (System) 09/06/2021 2....
Driver
Programs and drivers that might be restored. These programs might not work correctly after restore and might need to be reinstalled:
Description
Type
MiniTool Partition Wizard Free 12.5 12.5
Program
Close

With Windows repair tools, you may be able to roll your system back to a working state.


Lazesoft Windows Recovery Home
Lazesoft
Windows Recovery
Microsoft Windows 10 x64 Edition
Welcome
One Click Fix
BootCrash
LoadingCrash
RandomCrash
RestoreDisk
FinalSolution
RepairTools
Overview
Windows crashes can have many different symptoms and multiple causes. Lazesoft Windows Recovery provides a complete solution for repairing your Windows operating system. Please select the solution best matching your symptoms.
One Click Fix Crash Solution
A fast and easy way to fix the crash problem. We recommend the feature for novice users. This feature is also undoable. If you are not satisfied with the repair results, you can click <Undo> to cancel all the modification with this option.
Boot Crash Solution
When you start the computer, it ALWAYS crashes with a black screen, You are NEVER able to get to the Windows loading bar. You might observe an error message such as: "Ntldr is missing" or "error loading operating system", etc on the black screen.
Loading Crash Solution
When you start the computer, it ALWAYS crashes at the Windows loading bar on the welcome screen. You might observe freezing, rebooting repeatedly, a blue screen, etc.
Random Crash Solution
When you start the computer, it ALWAYS crashes at the Windows loading bar on the welcome screen. You might observe freezing, rebooting repeatedly, a blue screen, etc.

Lazesoft's Recovery Suite is our go-to tool for identifying common boot problems.

If none of these options work, you'll need to drop into a command prompt to continue troubleshooting. Choose Command Prompt and Windows will drop you into the temporary RAM drive (X:\) created by the Windows Recovery Environment (WRE). Begin by seeing if the Start-up Repair tool has managed to log the problem in the SrtTrail.txt file, which will help you target a solution. The file is stored on your Windows boot drive under Windows\System32\logfiles\srt\, but don't assume the boot drive has been assigned the letter C by the WRE.

To see which letter it has been assigned, type **'diskpart'** and hit Enter, then type **'list volume'** and hit Enter. Once verified, type the following, substituting C:\ with whichever drive letter it's been given:

```
cd C:\Windows\System32\logfiles\srt\
SrtTrail.txt
```

The file's contents will be displayed, allowing you to review its findings and pinpoint problems the Start-up Repair tool may have been able to identify but without being able to fix, for example, corrupt boot files.

When it comes to applying manual fixes, the bootrec tool is just one of several available to you from the Command Prompt. Others include diskpart, chkdsk, and DISM. Typing the tool's name and pressing Enter will bring up a list of supported commands for that tool, but if you find it all a little off-putting, check out the box to find out how to create a bootable Lazesoft Recovery disc or drive, then carry on.

A simpler fix

Once you've booted to the Lazesoft Recovery desktop, first take steps to copy any unprotected data on your drive to a backup drive. If you plan to copy it over the network, you'll first need to assign the network drive a letter: click Start and choose 'Map Network Drive' first. Specify its address (try its IP address in place of its server name if you can't connect), select a drive letter, and enter the required network credentials if necessary.

The Lazesoft File Manager icon on the desktop provides a simple two-pane file explorer tool for manually copying individual files and folders, or you can make use of the Data Recovery tool, which can transfer regular files as well as recover deleted files and files from lost partitions. Select your scanning level (choose 'Fast' for non-recovery scenarios), choose the drive containing your data and click Start Search. After a short period, you'll be able to search the drive by file path or file type, then select which files you want to recover before clicking 'Save Files' to select a drive and folder to copy them to.

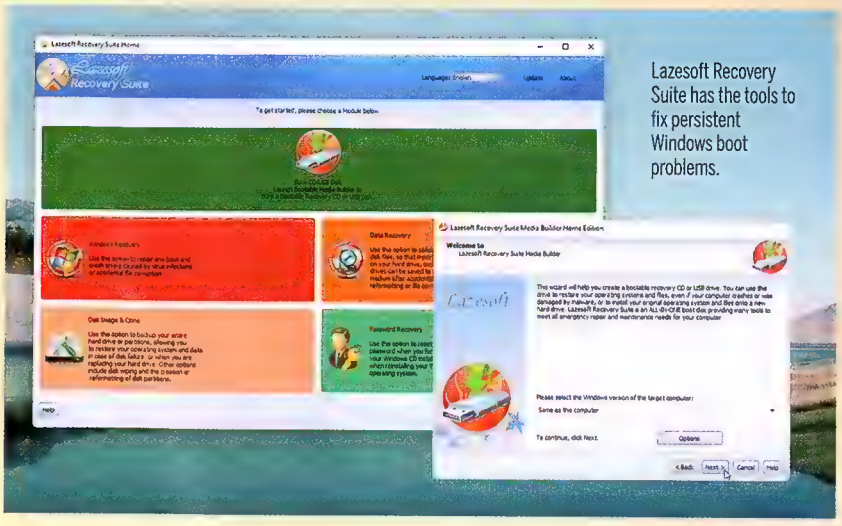
If you're not sure which files you might be missing, back up the entire drive: click 'Disk Image & Clone' followed by 'Backup (Drive to Image)'. Select drive C and click Next. Leave Full Backup selected and click Browse to select your destination followed by Start to take the backup. Should you need to recover files from this drive image in future, install Lazesoft on your PC, then launch it in Windows. Open 'Disk Image & Clone, then click 'Browse Drive Image File' under Drive Image.

Repair your Windows installation

With your failsafe backups in place, open Windows Recovery, select your Windows installation if necessary, and click OK. At the Overview screen, click the 'One Click Fix Crash Solution' option. Click 'One Click Fix' to run the wizard. Review the results and click Finish.

If the one-click fix doesn't solve your problem, examine the BootCrash tab, where you'll see a selection of individual tools from MBR Repair to Missing Windows File Repair. Select one and if it matches your symptoms, click the button to apply it. Failing that, the LoadingCrash tab offers more tools, including shortcuts to Windows tools like System Restore and System File Checker, as well as some of Lazesoft's own, such as the Registry Recovery tool. This latter tool will attempt to detect and fix Registry corruption. Some programs may need reinstalling if this succeeds, so use it as a last resort.

Windows Recovery helps steer you towards the appropriate solution for your symptoms. If the one-click option has no effect, take the time to select each tool and read its description, which includes a guide to the types of symptoms the tool can remedy. After all this, if you're still unable to get Windows to work, it's time to bite the



Lazesoft Recovery Suite has the tools to fix persistent Windows boot problems.

BUILD A RECOVERY DISC

Windows' built-in repair tools can only do so much, so if you find that they are falling short, then it's time to call in the cavalry.

Lazesoft Recovery Suite is our go-to tool when it comes to taking on stubborn boot problems. Not only does it offer a wider range of repair tools, but there are also tools for recovering data from crashed (but readable) drives as well as the option of taking a fail-safe image of your entire corrupted Windows installation. This ensures that you won't lose any files, even if you end up with no other choice but to hit the nuclear option.

In an ideal world, you'll have a Lazesoft recovery disc or USB flash drive ready to go but if not, you'll need access to a working PC. Browse **www.lazesoft.com** on that and click Download, choosing the free Home Edition download. Once that has downloaded, install the program and click on the 'Burn CD/USB Disk' option.

If your working PC is running a different version of Windows, select the correct version from the dropdown menu before clicking Next. Note, at the time of writing, version 4.5.1 of the software didn't explicitly support the latest version of Windows; however, we were able to install, build and boot from a disc using Windows 11. You can burn this to CD, copy it to a spare flash drive (2GB or larger), or create an ISO file you can subsequently add to your Ventoy boot disc.

Once created, test the media: restart your PC with it in the drive, then tap whichever key is listed to bring up the boot menu (typically F11 or F12). From here, select your USB drive – choose UEFI if offered the choice – and when the Windows Boot Manager appears, leave 'Lazesoft Live CD (EMS Enabled)' selected before hitting Enter.

bullet and look to repair or reinstall Windows. See the box for details.

Fix common Windows problems

Most issues with Windows are less severe, so let's take a look at a selection of common ones before resorting to more generic troubleshooting tools and techniques. First, what happens if Windows rejects your password or PIN when trying to log in? These days, virtually everyone will be logging on using their Microsoft Account, however, if you're still using a local account, then one possible option is to use the Lazesoft Recovery disc's Recover My Password tool to clear the account password and start from scratch with a new one.

If you're logging in with a Microsoft Account, then to go **https://account.live.com/password/reset** and follow the prompts to reset your password. Once done, you should hopefully be able to log into your Windows account again. As a side note, if you're trying to troubleshoot a problem in Safe mode, but Windows keeps rejecting your password, it may be because you changed your password after installing Windows on that PC, so you'll need to try and remember your original password and use that instead to log in.

Can't sleep, won't sleep

Does your PC struggle to stay asleep? Open an administrative command prompt by right-clicking the Start button. Choose Windows Terminal (Admin) in Windows 11. Type powercfg /lastwake and hit Enter. This will tell you the last thing to wake your PC, which can form the basis of your troubleshooting following our advice at the end of this feature. If you'd like to see which services, apps, or drivers can wake your PC, try powercfg /waketimers followed by powerfg /requests.

You can also use powercfg to provide a detailed report of your energy and power usage, including potential problems using the 'powercfg /energy' command. After 60 seconds, open the C drive and look for a file called 'energy-report.html', which you can also examine for clues to diagnose your wake-related problem.

USB issues

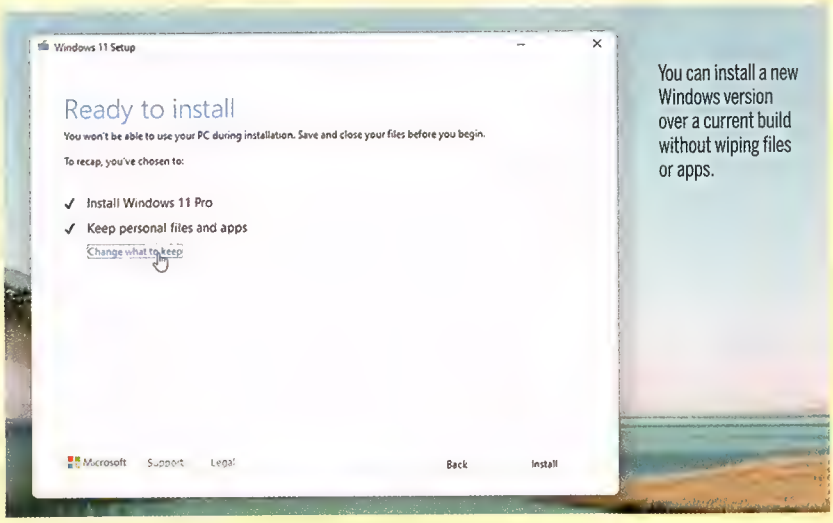
Sleep-related issues can often be traced to an errant USB device, which leads us to more generic USB issues that can cause problems. Some of these involve your USB chipset drivers, which vary according to your motherboard. Right-click Start and choose Device Manager, then expand the Universal Serial Bus controllers. Double-click each Host Controller in turn and switch to the Driver tab to identify the controller and its current driver version.

By default, Windows will install its own set of drivers for these controllers where possible – in most cases, that should be fine, but if not, go to your PC or motherboard manufacturer's website and see if there are dedicated USB or chipset drivers to download and install.

If you encounter any error codes for USB devices or ports in Device Manager, download USB Repair (**www.rizonesoft.com/downloads/**), which may be able to provide a swift resolution to your problem.

If you're struggling to identify what devices are connected to which USB ports, use the free HWiNFO (**www.hwinfo.com**) tool. From the main window, expand Ports > USB to view all hubs. Expand each one further beyond its Root Hub to determine which device is plugged into which controller. If certain devices on the same controller appear to be conflicting with each other, try moving them on to separate controllers.

A related issue may occur with devices you have plugged into your front-mounted USB ports. These ports are less 'stable' than the rear ones, particularly with wireless devices and those that draw their power from the USB port. Always try to plug these types of more permanent connections into the rear ports where possible, saving your front-mounted ports for USB flash drives and other easily removable devices.


Windows 11 Setup
Ready to install
You won't be able to use your PC during installation. Save and close your files before you begin.
To recap, you've chosen to:
Install Windows 11 Pro
Keep personal files and apps
Change what to keep
Microsoft
Support
Legal
Back
Install
You can install a new Windows version over a current build without wiping files or apps.

REPAIR OR REINSTALL?

Sometimes, you can't fix your Windows problem following any number of tools or steps.

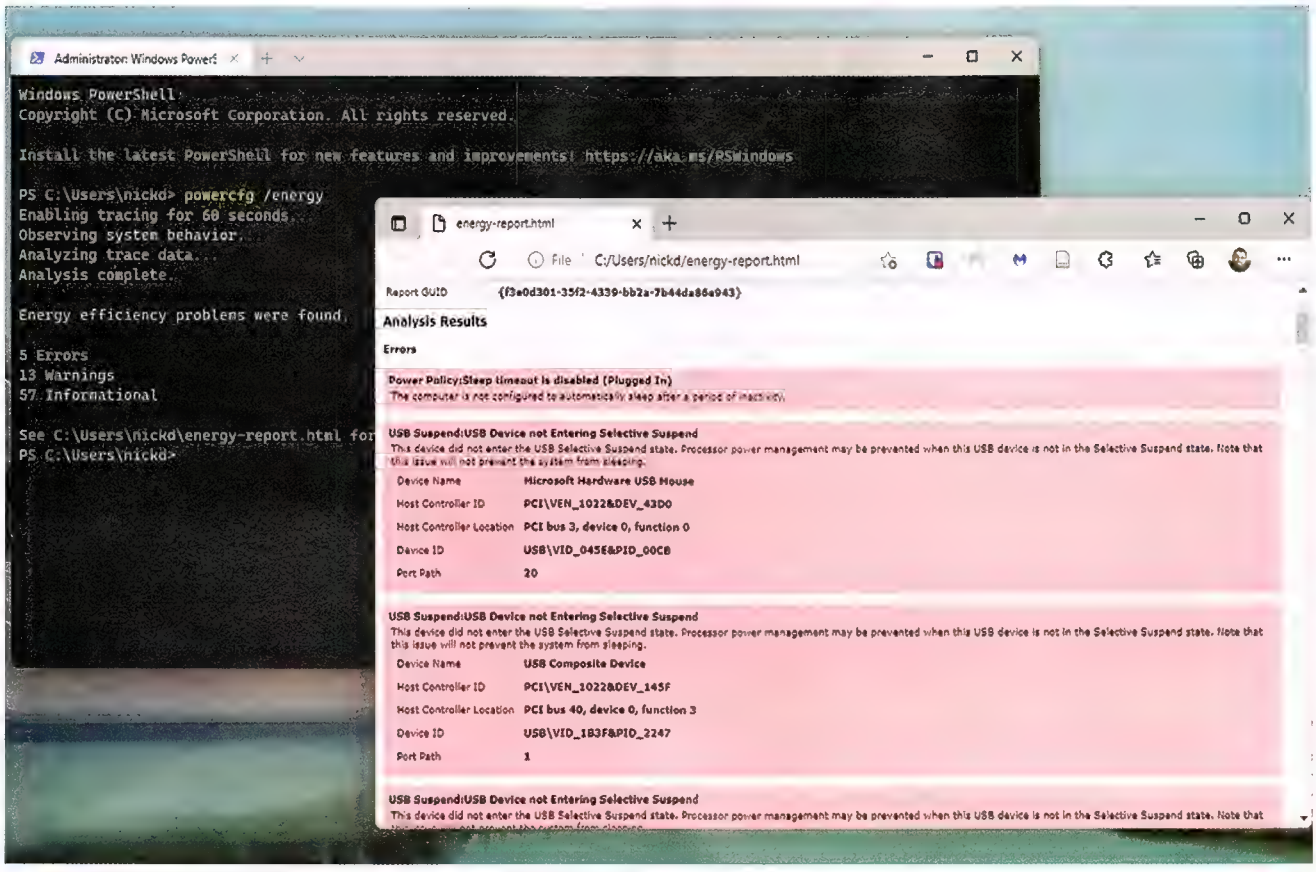
At times like these, it's tempting to reach for the 'nuclear' option and reinstall Windows from scratch, but sometimes you can get away by 'upgrading' your Windows installation by installing a fresh version over the top of your current build without wiping data, settings, or applications.

This 'repair' installation requires you to create Windows installation media – you can download the tool for burning a DVD or writing to a spare, unused 8GB flash drive from **https://www.microsoft.com/en-us/software-download/windows11** or **www.microsoft.com/en-us/software-download/windows10** depending on your version of Windows. Alternatively, Windows 11 users can download the ISO file directly, then double-click it to mount the file as a virtual DVD in File Explorer.

From here, open the drive and double-click setup.exe, then follow the prompts to start the installation process including downloading any updates if they're required.

After everything is ready, you'll be prompted what type of install you wish to perform. Make sure 'Keep personal files and apps' is selected before clicking Install (if necessary, click 'Change what to keep' to select it). From this point on, Windows will reinstall itself, rebooting when necessary to eventually return you to your desktop, with the problem hopefully fixed.

If you're looking for a more drastic fix, but one that doesn't involve losing any personal files on your system drive, you can also reinstall Windows via Settings – navigate to System > Recovery > Reset this PC. You'll see there's no option to preserve settings and apps, so only consider this if Windows is falling apart at the seams and you're unable to take final backups of data and your system using tools like Macrium Reflect; otherwise, update your backups one last time and consider wiping the drive clean and starting completely from scratch using your newly created installation media.


Administrator: Windows PowerS
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.
Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows
PS C:\Users\nickd> powercfg /energy
Enabling tracing for 60 seconds...
Observing system behavior...
Analyzing trace data...
Analysis complete.
Energy efficiency problems were found.
5 Errors
13 Warnings
57 Informational
See C:\Users\nickd\energy-report.html for
PS C:\Users\nickd>
energy-report.html
File C:/Users/nickd/energy-report.html
Report GUID {f3e0d301-35f2-4339-bb2a-7b44da86a943}
Analysis Results
Errors
Power Policy:Sleep timeout is disabled (Plugged In)
The computer is not configured to automatically sleep after a period of inactivity.
USB Suspend:USB Device not Entering Selective Suspend
This device did not enter the USB Selective Suspend state. Processor power management may be prevented when this USB device is not in the Selective Suspend state. Note that this issue will not prevent the system from sleeping.
Device Name Microsoft Hardware USB House
Host Controller ID PCI\VEN_1022&DEV_43D0
Host Controller Location PCI bus 3, device 0, function 0
Device ID USB\VID_045E&PID_00CB
Port Path 20
USB Suspend:USB Device not Entering Selective Suspend
This device did not enter the USB Selective Suspend state. Processor power management may be prevented when this USB device is not in the Selective Suspend state. Note that this issue will not prevent the system from sleeping.
Device Name USB Composite Device
Host Controller ID PCI\VEN_1022&DEV_145F
Host Controller Location PCI bus 40, device 0, function 3
Device ID USB\VID_183F&PID_2247
Port Path 1
USB Suspend:USB Device not Entering Selective Suspend
This device did not enter the USB Selective Suspend state. Processor power management may be prevented when this USB device is not in the Selective Suspend state. Note that

Troubleshoot Windows Update

If Windows Update refuses to work correctly, for example, if it throws up errors when you attempt to install an update or scan for updates, or you're struggling to install a specific update, then start by running the Windows Update troubleshooter to see what it finds: type 'windows update' into the search tool and click 'Find and fix problems with Windows Update'.

Click Next and wait while the tool scans for issues. If it finds and fixes any, click 'View detailed information' to find out more about the fix, then click Close, reboot, and try again. If the fix in question involves installing pending updates, but it's those updates refusing to install that is causing the problem, click 'Skip this fix' to keep searching for other potential issues.

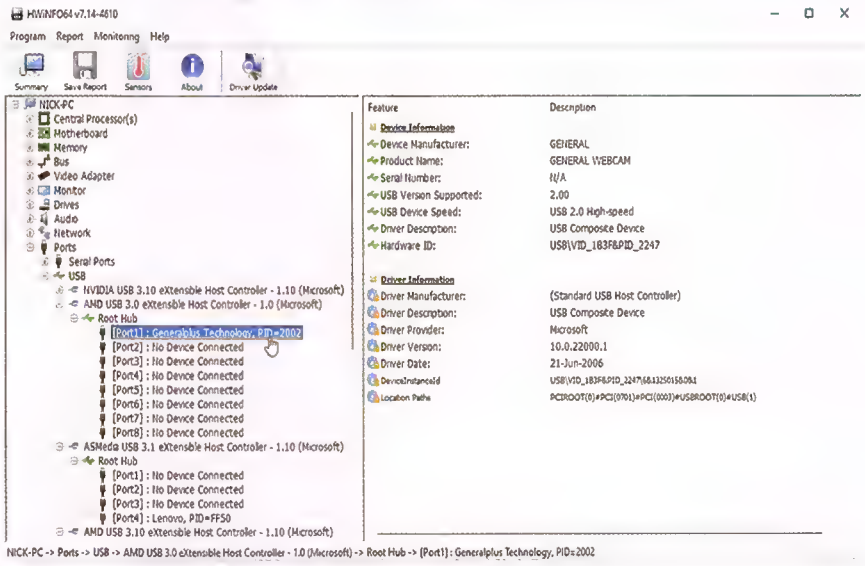
If the problem persists, you may need to perform some more drastic steps. Check out the box on the left for details of how to use the free Windows Repair tool to attempt a fix for this – and other Windows-related problems.

If you are struggling to update to a newer version of Windows (or the latest feature update), use the Update Assistant (**www.microsoft.com/en-us/software-download/windows10**) to handle the process for you. Be patient, this process may take several hours and involve multiple reboots.

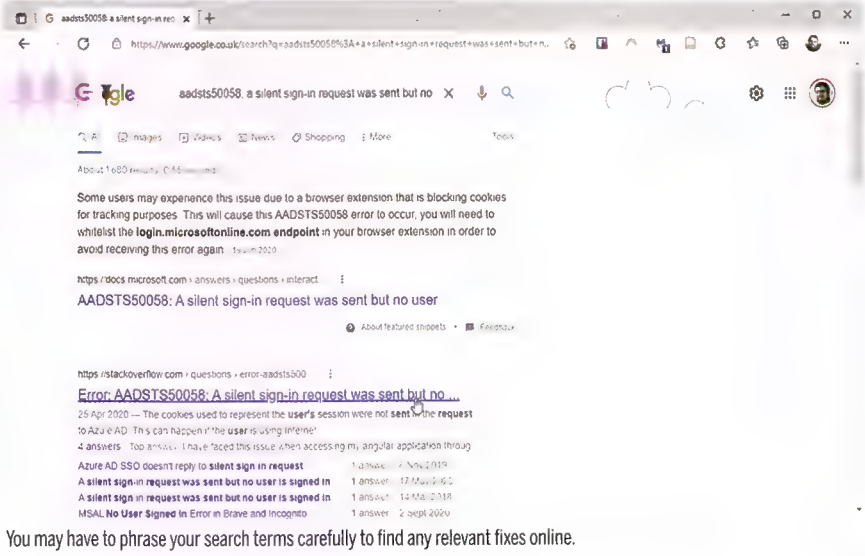
Troubleshoot individual updates

Often, the problem isn't with Windows Update itself, but a specific update that refuses to install. You may get an advanced warning, such as a message during reboot that

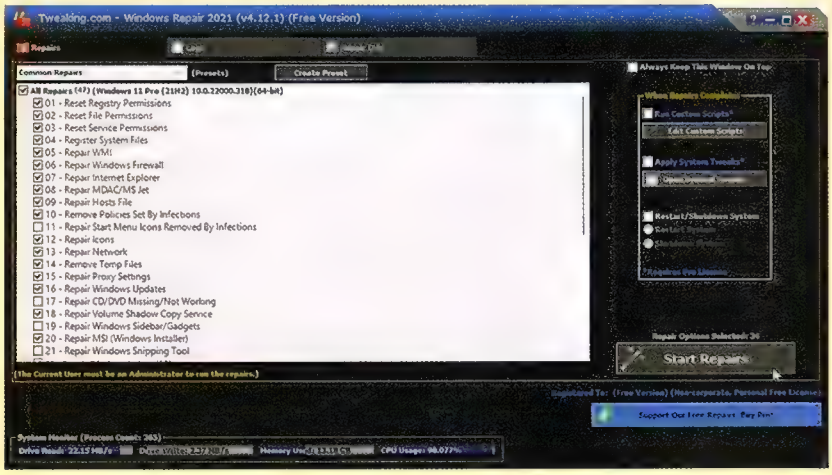
If your PC is struggling to stay asleep, you can analyze what's waking it up.


HWiNFO64 v7.14-4610
Program Report Monitoring Help
Summary Save Report Sensors About Driver Update
NICK-PC
Central Processor(s)
Motherboard
Memory
Bus
Video Adapter
Monitor
Drives
Audio
Network
Ports
Serial Ports
USB
NVIDIA USB 3.10 eXtensible Host Controller - 1.10 (Microsoft)
AMD USB 3.0 eXtensible Host Controller - 1.0 (Microsoft)
Root Hub
[Port1] : Generalplus Technology, PID=2002
[Port2] : No Device Connected
[Port3] : No Device Connected
[Port4] : No Device Connected
[Port5] : No Device Connected
[Port6] : No Device Connected
[Port7] : No Device Connected
[Port8] : No Device Connected
ASMedia USB 3.1 eXtensible Host Controller - 1.10 (Microsoft)
Root Hub
[Port1] : No Device Connected
[Port2] : No Device Connected
[Port3] : No Device Connected
[Port4] : Lenovo, PID=FF50
AMD USB 3.10 eXtensible Host Controller - 1.10 (Microsoft)
Feature Description
Device Information
Device Manufacturer: GENERAL
Product Name: GENERAL WEBCAM
Serial Number: N/A
USB Version Supported: 2.00
USB Device Speed: USB 2.0 High-speed
Driver Description: USB Composite Device
Hardware ID: USB\VID_183F&PID_2247
Driver Information
Driver Manufacturer: (Standard USB Host Controller)
Driver Description: USB Composite Device
Driver Provider: Microsoft
Driver Version: 10.0.22000.1
Driver Date: 21-Jun-2006
DeviceInstanceId
Location Paths
NICK-PC -> Ports -> USB -> AMD USB 3.0 eXtensible Host Controller - 1.0 (Microsoft) -> Root Hub -> [Port1] : Generalplus Technology, PID=2002

HWiNFO can help identify potential conflicts between USB devices.


aadsts50058. a silent sign-in request was sent but no
Some users may experience this issue due to a browser extension that is blocking cookies for tracking purposes. This will cause this AADSTS50058 error to occur, you will need to whitelist the login.microsoftonline.com endpoint in your browser extension in order to avoid receiving this error again.
https://docs.microsoft.com › answers › questions › interact...
AADSTS50058: A silent sign-in request was sent but no user
https://stackoverflow.com › questions › error-aadsts500...
Error: AADSTS50058: A silent sign-in request was sent but no ...
26 Apr 2020 — The cookies used to represent the user's session were not sent in the request to Azure AD. This can happen if the user is using Internet
4 answers
Azure AD SSO doesn't reply to silent sign in request
A silent sign-in request was sent but no user is signed in
A silent sign in request was sent but no user is signed in
MSAL No User Signed In Error in Brave and Incognito

You may have to phrase your search terms carefully to find any relevant fixes online.


Tweaking.com - Windows Repair 2021 (v4.12.1) (Free Version)
Repairs
Common Repairs
(Presets)
Create Preset
All Repairs (47) (Windows 11 Pro (21H2) 10.0.22000.318)(64-bit)
01 - Reset Registry Permissions
02 - Reset File Permissions
03 - Reset Service Permissions
04 - Register System Files
05 - Repair WMI
06 - Repair Windows Firewall
07 - Repair Internet Explorer
08 - Repair MDAC/MS Jet
09 - Repair Hosts File
10 - Remove Policies Set By Infections
11 - Repair Start Menu Icons Removed By Infections
12 - Repair Icons
13 - Repair Network
14 - Remove Temp Files
15 - Repair Proxy Settings
16 - Repair Windows Updates
17 - Repair CD/DVD Missing/Not Working
18 - Repair Volume Shadow Copy Service
19 - Repair Windows Sidebar/Gadgets
20 - Repair MSI (Windows Installer)
21 - Repair Windows Sniping Tool
(The Current User must be an Administrator to run the repairs.)
Always Keep This Window On Top
When Repairs Complete
Run Custom Scripts
Edit Custom Scripts
Apply System Tweaks
Restart/Shutdown System
Start Repairs
Support Our Free Repairs - Buy Pro!

ONE-STOP FIXIT TOOL

Looking for a tool that provides access to dozens of fixes for common Windows problems?

Go to www.tweaking.com and download the free version of Windows Repair Tool.

WRT runs best in Safe mode – the quickest way to get there is to press Win-R, type msconfig then hit Enter, then switch to the Boot tab, tick 'Safe boot', and select Network. Click OK followed by Restart, and Windows will reboot into Safe mode (you'll need to log in with your full password, not a PIN number or other form of ID). Once logged in, launch the Windows Repair Tool.

After the program has performed its start-up check, click 'I Agree' to go to the main screen. Work your way through various health checks, a power reset, plus scans of your Windows package files, system reparse points, and environment variables (you can ignore issues with reparse points, so skip the repair option).

There are also options to run full disk checks and a system file check – both are recommended. Reboot whenever prompted and you'll come back to Safe mode to carry on where you left off.

Once the basic tests are complete, select Backup Tools and take both a Registry backup and a System Restore point. Now select the 'Repairs – Main' tab to view the choices. Five presets exist to perform specific repairs. Click any option and you'll be shown a list of repairs with descriptive names like 'repair icons' or 'reset file permissions'. Use the Repair Info to find out more about individual repairs.

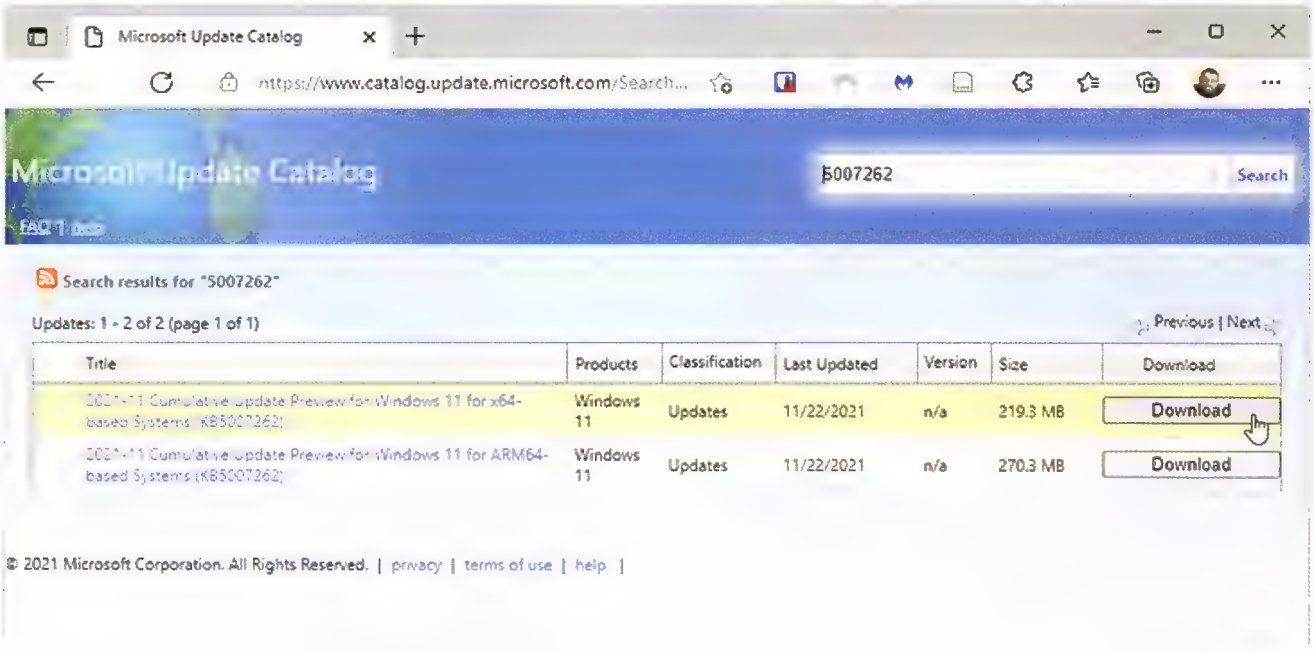
Select ones you think are applicable, then click Start Repairs. After you've (hopefully) fixed your problems, open msconfig again, and untick 'Safe boot' under the Boot tab to allow you to reboot into Windows proper to verify things are working correctly.

Windows is reversing a failed update, or your PC may keep attempting to install updates after every reboot. If the problem persists, it's time to take further action.Check the status of updates via the Windows Update tool. Simply click 'View update history', where you'll see a list of previously installed updates and whether they were successful or not. If multiple updates are failing, then it's likely only one of them is the culprit.

Start by trying to download and install the troublesome update manually. Go to **www.catalog.update.microsoft.com** and search for the update number (including KB). You'll be given a list of matches based on Windows version, plus system architecture – x64 is for 64-bit versions of Windows, x86 for 32-bit. Download the file to your hard drive, then double-click it and follow the instructions to install it.

If this doesn't work, you'll need to dig deeper. Make a careful note of the error code and the updated KB number. Google the code, try it with "Windows Update", your version of Windows, the KB number, or just on its own to see what you find. Ignore ads and focus on genuine websites, including reputable sources such as **https://answers.microsoft.com**. Focus on newer results first, particularly if they correspond to your specific KB number.

With a bit of luck, you'll stumble on a solution found by others. Often, there's no rhyme or reason to certain updates failing, but if all of the troubleshooting techniques we have described here fail to yield a solution, don't panic. online communities can steer you towards the solution.



If automatic updates are an issue, you can try downloading troublesome ones manually.

File Explorer glitches

Problems with File Explorer, particularly where it stops responding or takes an age to open certain folders (or indeed any folder), could mean any number of things. Start your focus on the health of your hard drives, use a tool such as HDDScan (**https://hddscan.com/**) to give them the once over physically, then schedule disk checks from an administrative command prompt:

chkdsk c: /f/r

When checking your system drive, you'll be prompted to schedule the check after the next reboot. Do so, reboot and if you're lucky, errors will be found and repaired, and File Explorer will start working properly again.

If File Explorer 'resets' itself or stops responding when you right-click an item, then chances are the problem is with a third-party app that's tied itself into Explorer, for example, by adding items to the context menu that appears when you right-click a specific filetype or folder. If you recently installed a new app, focus on troubleshooting that with our guide below.

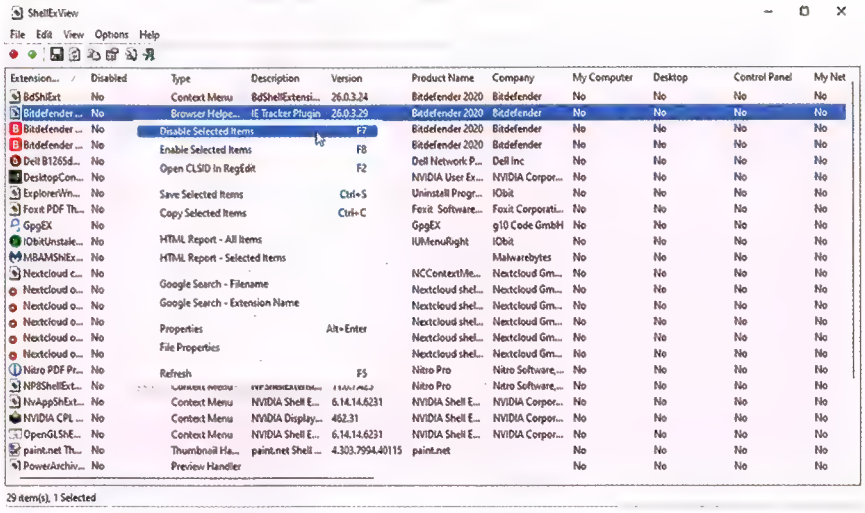
If you can't easily identify the app in question, look for a tool that can temporarily disable all third-party File Explorer plugins. One such example is ShellExView (**www.nirsoft.net/utils/shexview.html**), which we've successfully tested on Windows 11. Choose the 'Download ShellExView for x64' link, then unzip and run the program. Choose 'Options > Hide all Microsoft Extensions' to remove all but those plugins added by a third party, then you can go through the list looking for possible culprits. If all else fails, select all the items in the list, then press F7 to disable them all.

If the problem goes away, you know it's one of these items that's to blame. Re-enable them one at a time or in groups until the problem returns, and then deal with the offending item by leaving it disabled, checking for a program update to fix the issue, or removing the app entirely.

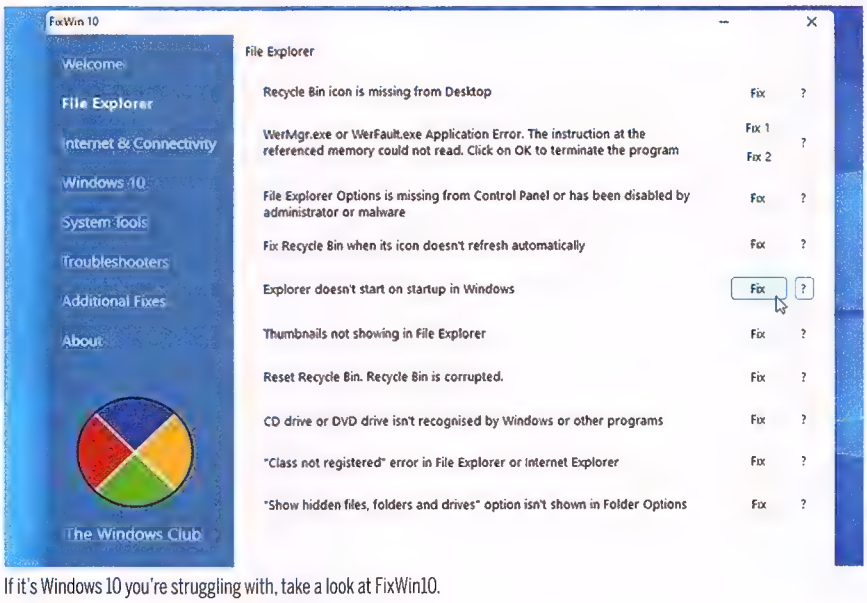
Dig deeper

If none of the above techniques have helped you resolve your Windows problem, don't panic. Start by checking the box on the **Tweaking.com** Windows Repair tool, which offers fixes for a variety of problems. Other programs offering potential one-click fixes to many issues include FixWin10 (**www.thewindowsclub.com/fixwin-for-windows-10**) and Complete Internet Repair (**www.rizonesoft.com/downloads/**).

The art of troubleshooting problems is not about knowing that problem A is

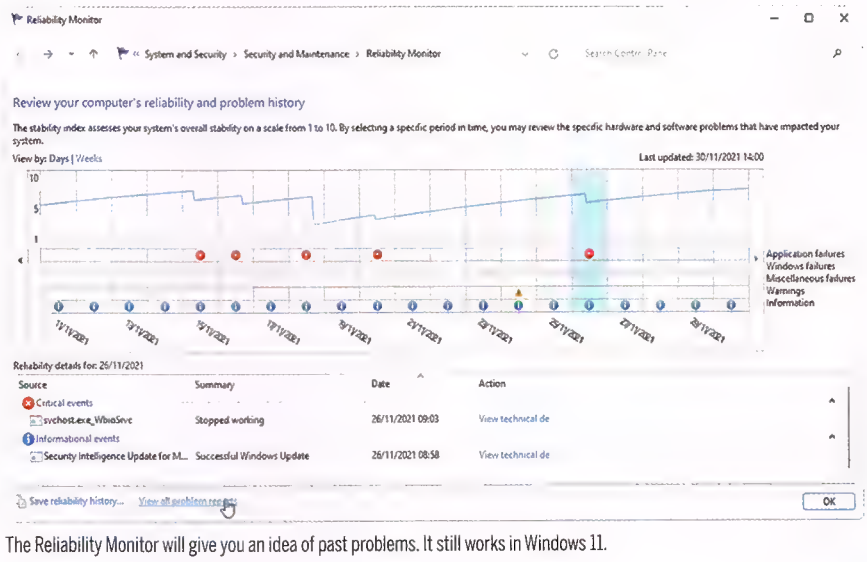

ShellExView
File Edit View Options Help
Extension... / Disabled Type Description Version Product Name Company My Computer Desktop Control Panel My Net
Disable Selected Items F7
Enable Selected Items F8
Open CLSID in RegEdit F2
Save Selected Items Ctrl+S
Copy Selected Items Ctrl+C
Properties Alt+Enter
File Properties
Refresh F5
HTML Report - All Items
HTML Report - Selected Items
Google Search - Filename
Google Search - Extension Name
29 item(s), 1 Selected

Use ShellExView to disable third-party File Explorer plugins while you identify the culprit.


FixWin 10
Welcome
File Explorer
Internet & Connectivity
Windows 10
System Tools
Troubleshooters
Additional Fixes
About
The Windows Club
File Explorer
Recycle Bin icon is missing from Desktop
WerMgr.exe or WerFault.exe Application Error. The instruction at the referenced memory could not read. Click on OK to terminate the program
File Explorer Options is missing from Control Panel or has been disabled by administrator or malware
Fix Recycle Bin when its icon doesn't refresh automatically
Explorer doesn't start on startup in Windows
Thumbnails not showing in File Explorer
Reset Recycle Bin. Recycle Bin is corrupted.
CD drive or DVD drive isn't recognised by Windows or other programs
"Class not registered" error in File Explorer or Internet Explorer
"Show hidden files, folders and drives" option isn't shown in Folder Options
Fix
Fix 1
Fix 2

If it's Windows 10 you're struggling with, take a look at FixWin10.

The art of troubleshooting problems is not about knowing that problem A is fixed by solution B but rather understanding the tools and techniques you need to find solution B.



The Reliability Monitor will give you an idea of past problems. It still works in Windows 11.

fixed by solution B but rather understanding the tools and techniques you need to find solution B. You'll not only acquire the knowledge required to understand which Windows tools will be of most use to any specific issue, but you'll also learn how to harness the power of the web to track down step-by-step solutions and remedies you can apply or adapt to your own circumstances.

Gather pertinent information

Step one involves diagnosing and describing the problem in such a way that you gain the information you need to go hunting for a solution if one doesn't present itself. The best problems to troubleshoot are those that can be linked to a specific program, have an obvious cause, and come with a detailed error message (including error code and filename). If you're lucky enough to get one of these, note down all the details and skip to the section on using the web.

Sadly, that's not always possible – you might be told that your program has encountered a problem and had to close, but nothing else is volunteered. Your PC might freeze for no apparent reason or throw up a blue screen error before restarting. These all indicate an underlying problem, but where do you go to find out more information?

Windows records major events, including warnings and errors, in a series of logs. To access the relevant ones, type 'reliability' into the Search box and click 'View reliability history' to open the Reliability Monitor. You'll see a chart rating your PC for stability and providing a summary of failures (apps, Windows, and miscellaneous), warnings, and information. These provide a list of key events recorded. Make a note of the event, then click 'View technical details' to access information such as a program name, exception code, and type of error. Jot this down. If nothing is forthcoming, try widening your search to the entire log by right-clicking Start and choosing Event Viewer. Once it's loaded, expand the Critical Error and Warning sections to find log entries whose time stamps coincide with the problem you encountered.

Search the web

Your obvious first port of call for a solution is Microsoft Support (**https://support.microsoft.com/en-us**) or the website of the program or hardware device that's causing you grief. If this yields nothing, expand your search to Google.

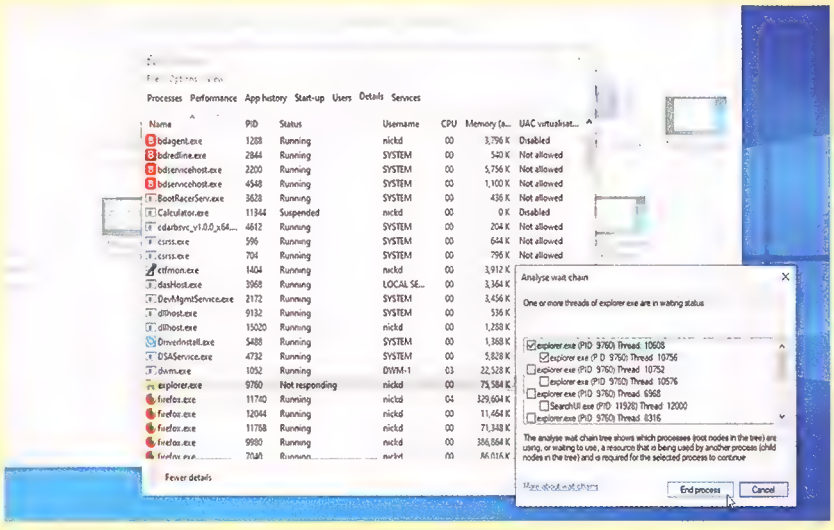
When searching the web for a solution to your problem, the key to finding potential fixes is knowing what words to include in your searches. Enter too many search terms and you'll get no results; enter too few and you'll find hundreds of results, most of which won't be relevant to your particular problem.

Rather than wade through these results, it makes sense to refine your search to see if you can narrow down the search results without missing out on potentially useful sites. Try entering words that are related to your problem: error messages, program names, the version number of Windows 10 such as 21H2, hardware, anything you think is relevant. When entering filenames or error codes, make sure you enter them exactly as they appeared on-screen. A frequent mistake is to type the letter O instead of the number 0 (zero).

Don't assume the first search results displayed are necessarily most relevant to your problem. Be prepared to scroll through a number of pages clicking promising links before deciding whether to refine your search terms further.

If you've pared your keywords down to the bare minimum in order to get a meaningful number of hits, but are still having no luck finding a solution, consider adding other possible relevant keywords to your search terms. If your problem is sound-related, for instance, including the name of your audio device might help you target a solution quicker.

Use Device Manager or HWiNFO to identify model names and drivers in case it's relevant, while program version numbers can be gleaned from Settings > Apps (click an entry to reveal its exact version number). ■



TROUBLESHOOT FREEZES

There you are, clicking or typing away and things suddenly grind to a halt, the screen loses focus and the dreaded "not responding" message appears.

Step one is to be patient: if you have lots of programs running, then Windows can get in a temporary jam while it attempts to juggle resources. After a short period, things free themselves, at which point, you can save your file and continue.

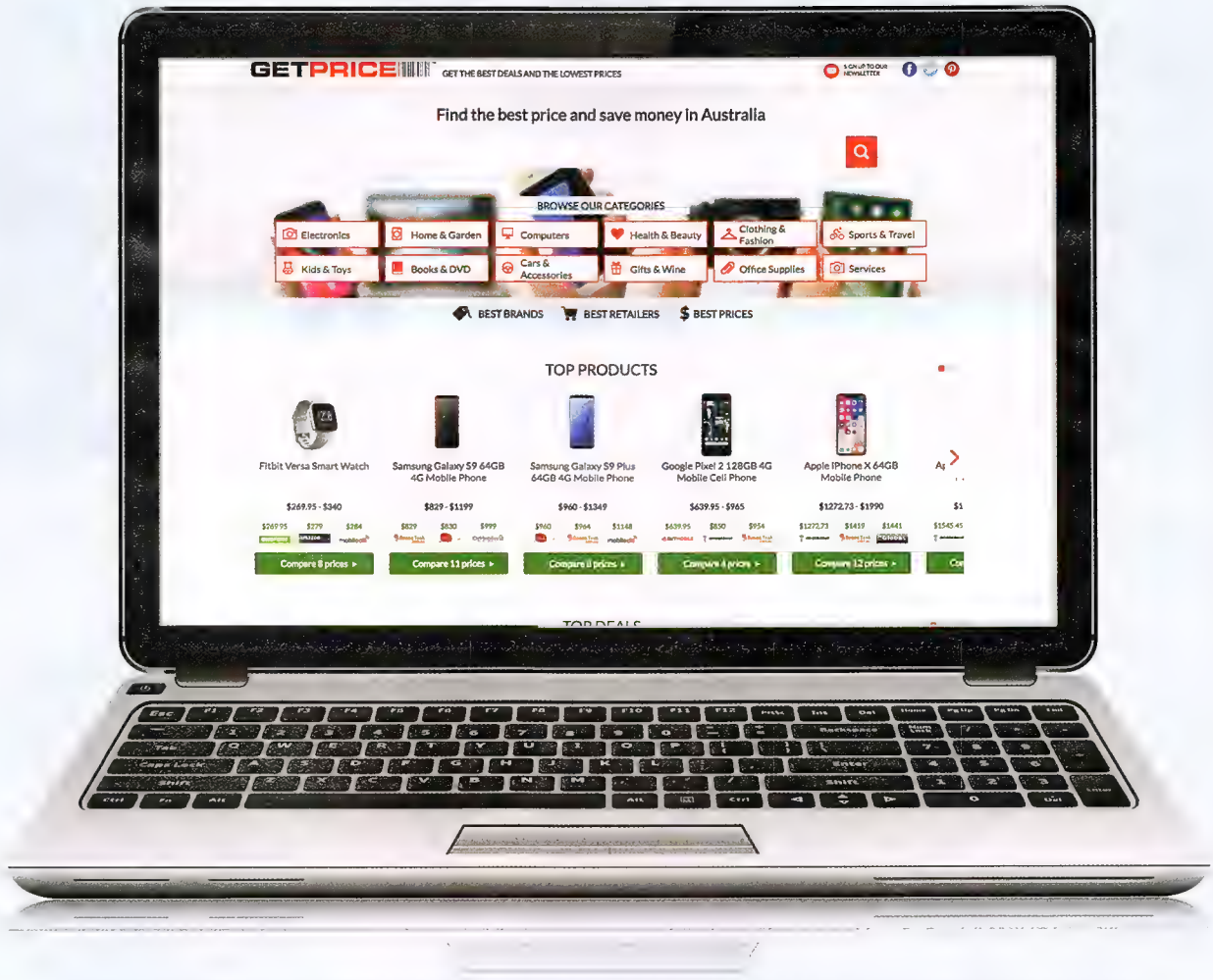
But sometimes, the freeze doesn't end. If Windows hasn't already invited you to either close or restart the program, then try clicking its red close button once or twice. Again, be patient, but if nothing happens, try pressing Ctrl-Alt-Del and wait for the screen to blank before selecting Task Manager from the list of options.

When Task Manager appears, click More Details, if it's visible. Any non-responsive program should be highlighted – from here, you can attempt to close it by selecting the process and clicking the 'End task' button or, if you'd like to try and recover it, right-click it and choose 'Go to details'.

This will take you to the Details tab, where processes are listed with more information on their status (running or suspended), the user who launched them (typically you, SYSTEM, or a SERVICE), and a PID (Process ID).

Right-click the non-responding thread and choose 'Analyse wait chain'. This will list any threads that are using or waiting to use resources being used elsewhere, which can result in the program freezing. Clicking End Process here may be enough to free the program without crashing it, but be prepared for the entire program to close.

Sometimes Task Manager appears to have no effect. In these circumstances, you may be forced into a reboot. Before doing so, attempt to close all other programs and processes (including those running in the Taskbar Notification area) by normal means to minimise the damage and improve your chances of avoiding bigger problems.



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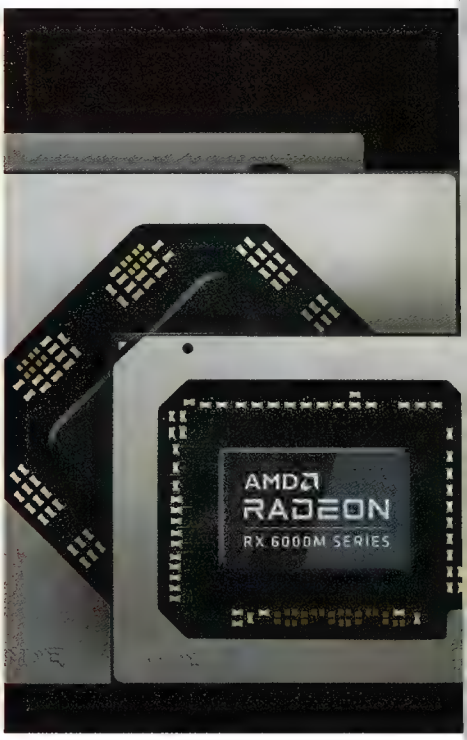
We've reviewed an example of AMD's new 6500 XT graphics card in this issue (page 34).



System news

Mark Williams always enjoys CES, and 2022's show was no different!

CES kicked us off in early January for another year of cool tech and as usual there was plenty of announcements and interesting products on show. Here are some of the highlights that piqued my interest.

AMD

AMD was the first cab off the rank and boy did it deliver. First up was the announcement of its new Ryzen 6000 series mobile processors, which finally ditch the ageing Vega graphics architecture for RDNA2 as is found in the latest graphics cards and consoles. As a result, AMD is claiming an easy 2x increase in IGP performance with games and 1.3x performance for CPU tasks, thanks to 5GHz boost clocks on Zen3+ cores.

A new S-class of mobile discrete GPU (dGPU) was announced. These RX6000S mobile chips will go into thin and light class laptops.

At the top of the line-up is the new, more powerful M-class dGPUs, with the top RX 6850M XT being seven percent faster than AMD's previous best RX 6800M. With 14 percent faster memory, seven percent faster clock speeds and with all these new chips built on TSMC's 6nm process these should offer up some fantastic performance and battery life figures.

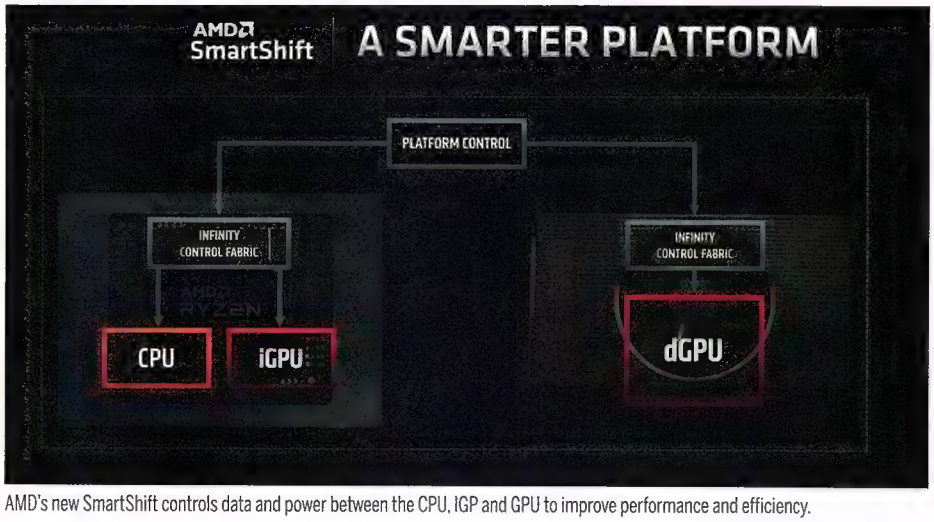
Along with improvements to its AMD Advantage framework for OEMs, AMD showed off some cool new tech for laptops including: Smartshift Max, which will be better able to balance the power distribution between CPU and dGPU for performance gains of up to 10 percent; SmartShift Eco, which allows the laptop to automatically swap running games from the dGPU to the IGP for better battery life on the go; and SmartAccess Graphics, which implements a graphics multiplexer (MUX) switch that allows either the dGPU or IGP to directly drive the monitor, instead of the dGPU output being routed through the IGP providing up to a 15 percent performance gains.

On the desktop side of things, the RX 6500XT was announced. Built on TSMC's 6nm process, aimed at the entry level with a high 2.6GHz game clock, 16 compute units, 16MB of Infinity cache and a PCI-E 4.0 x4 interface and lacking H264/HVEC encoding and AV1 decoding, this card makes a lot of compromises to get its MSRP to just US$200 (again, no Au pricing announced yet).

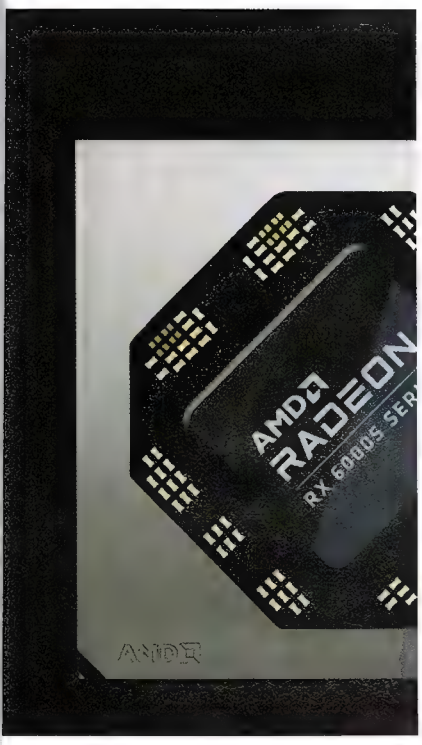
MARK WILLIAMS
Mark is an IT professional with a strong interest in voiding warranties.

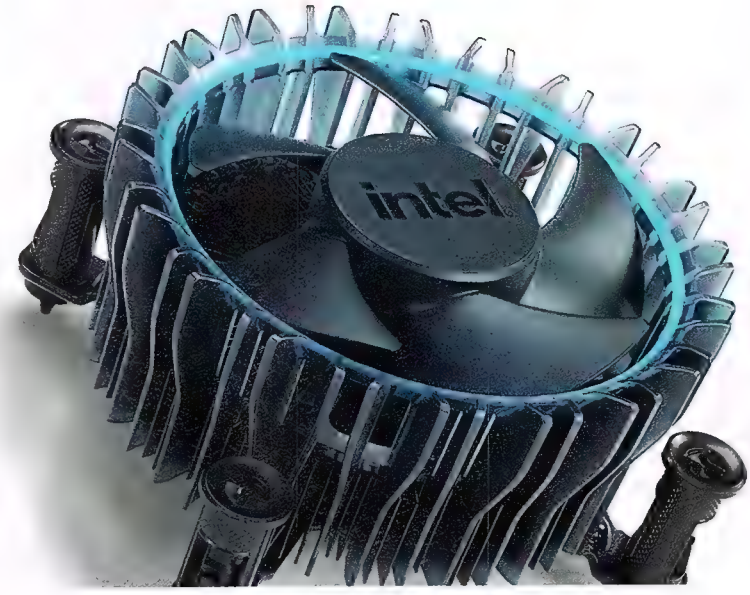
For CPUs it seems AMD is creating one last hoorah for its AM4 socket platform with a new Ryzen 5800XT3D CPU coming in Q2 of 2022. Claiming to match the 12900K in gaming with 3.4GHz/4.5GHz base/boost clocks, 8-cores and 16-threads, 105W TDP, 32MB 2D cache + 64MB 3D V-Cache for 96MB total. The new V-cache-touting CPU will be the ultimate AM4 CPU for gamers.

AMD's last announcement was about its long-rumoured Zen 4 powered AM5 socket CPUs. Coming in the second half of 2022 Ryzen 7000 series CPUs will sport PCI-E 5.0, switch to an LGA1718 socket and will use TSMC's 5nm process, with AMD's CEO Lisa Su showing a live game demo claiming an all-core boost of 5GHz on current engineering samples.



AMD's new SmartShift controls data and power between the CPU, IGP and GPU to improve performance and efficiency.





Left: Designed for thin and light notebooks, AMD's new RX6000S is an efficent and low power discrete GPU.
Right: After many years we finally have a new heat sink fan that will come bundled with many Intel CPUs.

Intel

Intel announced an astounding twenty-two new desktop CPU SKUs. All non-K variants of its existing Alder Lake 12th Gen line-up. One K-variant that was announced was the Core i9 12900KS featuring a crazy 5.5GHz single core turbo boost clock. The non-K variants will come with Intel's newly designed Laminar heatsink fans, which look quite nice and perform a tad better than Intel's previous stock coolers, too.

Intel also announced eight new 12th Gen H-series laptop CPUs, half of which feature six performance and eight efficiency cores in the i9 and i7 range boosting up to 4.7 - 5.0GHz. And three i5 processors that reduce the performance core count to just four while boosting up to 4.5GHz.

Like AMD, Intel announced its own laptop platform-specific technologies to improve battery life and performance.

A collection of technologies all under its new Deep Link umbrella name, Intel announced is Dynamic Power Share to balance power distribution across the CPU and discrete Arc GPUs. Hyper Encode for video editing allows video encoding to spread the encoding workload across both the IGP and dGPU at the same time, allowing for 1.4x faster encode times.

New motherboard chipsets to finally fill out the mid- and entry-tier desktop segments were also announced with B660, H670 and H610 chipsets all shown. B660 is certainly looking tasty for budget or value-oriented systems and customers.

Asus announced a DDR4 to DDR5 conversion kit, though it's undecided if this will make it to market.

Nvidia

Nvidia's 45 minute presentation ultimately boiled down to just a couple of short minutes briefly introducing new products in the RTX 3050 and RTX 3090 Ti lines for desktop, and the RTX 3080 Ti and 3070 Ti laptop GPUs.

The RTX 3050 carries a US$250 MSRP (no Au pricing available at the time of going to press) and sports 8GB of GDDR6 and finally brings its RTX technologies to the entry level.

The RTX 3090 Ti will have 24GB of 21Gbps GDDR6X memory, possibly implying it is using Micron's new double density memory modules. Meaning Nvidia could remove the thermally troublesome rear memory modules from the back of the card, which would be a good thing for stability and longevity of these cards. We'll have to wait and see.

The Nvidia 3090 Ti would have been inevitable in any other era, now it just means one more card we'll struggle to find and buy.

Others

Asus demonstrated an interesting prototype DDR4 to DDR5 conversion kit. Allowing DDR4 modules to be placed into DDR5 slots via a converter riser card. As DDR5 modules have power regulation built into them, the converter takes on the power regulation for the DDR4 modules as well as the signalling trickery.

The converter cards add significant height to the memory modules, limiting CPU cooler compatibility and it requires a special motherboard BIOS to work. Asus is gauging community enthusiasm before considering bringing this kit to market.

Lastly CyberPowerPC showed off an impressive looking Kinetic series PC chassis that has 18 individual moving servos (six for each of the three front fans) controlling the front vents of the case. Opening the front of the case up like some kind of flower from a Transformers movie when more airflow and cooling performance is needed and closing when it doesn't for a more interesting aesthetic to the chassis front fascia. ■

Market snapshot

A sampling of PC systems available this month.

$2,099 – tinyurl.com/APC504PCC

PC CASE GEAR REAPER 6600 XT

Offering a decent amount of performance for what these days is considered a more value-oriented system, this build keeps the budget in check while giving a quite well-rounded system. The CPU is the weaker of the processor pairing; now two generations old it'll hold up well enough in games thanks to its six cores, but being long in the tooth, to prevent it becoming the bottle neck in the latest games you'd be best off loading up the graphics card with 1440p resolutions and higher quality effects to keep the GPU working hard, reducing CPU demand. The memory kit is over specced and thus a little wasted in this system, as this CPU and motherboard combo will only support 2666MHz. It would be worth exploring lowering the memory timings to make up the lost potential. With adequate storage and power supply, this system is good value.

CPU: Intel Core i5 10400F; Cooler: OEM; **Motherboard:** Asus Prime B560M-A/CSM; **Graphics:** PowerColor Radeon RX 6600 XT Fighter 8GB; **Memory:** Team T-Force Delta RGB 16GB 3600MHz CL18 DDR4; **Storage:** Team MP34 M.2 NVMe SSD 512GB, Seagate Barracuda 2TB HDD; **PSU:** Phanteks PH-P550GF 550W; **Case:** Phanteks Eclipse P300A RGB Mesh Edition TG.

$1,449 – tinyurl.com/APC504PLE

PLE COMPUTERS PRIME

There's no way around it, the chassis for this system is about as square and boring as you can get, but considering the price, looks aren't a consideration. The CPU is a couple of years old now and only quad core, so as long as you only intend to do light productivity work, web browsing or run less demanding game titles it'll do ok, but it will hamper performance in newer bigger budget titles.

The graphics card is equally as entry level. With just 4GB of VRAM it's only good for 1080p gaming, but for many that's all that's required. With the motherboard and power supply also equally entry level, upgrading this system in the future would be challenging and bordering on a waste of money. With a roomy 1TB SSD, so long as you don't ask much of this system it should serve you well for a long time.

CPU: Intel Core i3 10100; Cooler: OEM; **Motherboard:** Asus Prime H510M-A WIFI; **Graphics:** Zotac Gaming GTX 1650 OC 4GB; **Memory:** GeIL Orion 16GB DDR4 C16 3000MHz; **Storage:** WD Blue SN550 1TB NVMe M.2 SSD; **Power Supply:** eVGA GD Series 500W; **Case:** Corsair Carbide 100R.

$2,999 – tinyurl.com/APC504MWV

MWAVE RESPAWN NINJA ELITE Z690

An interesting system namely because of the very performant 12600K CPU (which is only a couple of percentage points behind Intel's best in gaming) paired with a very middling to lower tier graphics card in the RTX 3060. Seated in a decent Z690 motherboard with lots of M.2 expansion and DDR4 support, this system is great for riding out the chip shortage, with a graphics card that's good enough for regular 1440p gaming. Once the GPU shortage ends and graphics cards return to normal prices, this system would be perfect for a GPU upgrade later to fully stretch the system's legs. The 32GB of RAM is great future-proofing and the 1TB SSD plus HDD combo offers up ample space for the longer term as well. A well specced power supply and AIO cooler make this a great system for the smart enthusiast gamer on a budget seeking a longer-term gaming rig.

CPU: Intel Core i5 12600K; **Cooler:** EKWB EK-AIO 360 D-RGB 360MM; **Motherboard:** Gigabyte Z690 UD AX **Graphics:** Gigabyte GeForce RTX 3060 Gaming OC 12GB; **Memory:** GeIL Orion RGB 32GB DDR4 3200MHz **Storage:** Kingston KC2500 1TB M.2 PCIe NVMe SSD, Seagate 2TB BarraCuda HDD; **Power Supply:** Asus ROG Strix 750W; **Case:** MSI MPG Velox 100P Airflow.

$6,999 – tinyurl.com/APC504SCO

SCORPTEC COMPUTERS VENGEANCE RTX 3080 TI

For the demanding gamer that plays the latest titles daily and wants the best experience, this system is where it's at.

With Intel's latest top end CPU and the RTX 3080 Ti, you simply can't ask for much more in a gaming rig for raw performance. The 12GB frame buffer on the graphics card solves the RTX 3080's VRAM issues at 4K, so 4K or running multiple monitors at 1440p (or higher) will be easy. Its god to see hefty 360mm AIO cooling for the CPU, the 12900K is especially power hungry and thus gets very hot, particularly in heavily threaded productivity workloads. The motherboard is top end and well featured. The RAM is capacious as is the mass storage. Though in a gaming focused system the HDD is a little out of place in this price category. Dropping that and instead having a 2TB SSD would've been preferable.

CPU: Intel Core i9 12900KF; **Cooler:** Corsair iCue H150i RGB Pro XT; **Motherboard:** Gigabyte Z690 Aorus Master **Graphics:** Gigabyte Gaming GeForce RTX 3080 Ti OC 12GB; **Memory:** Corsair Dominator Platinum RGB 32GB 5200MHz DDR5; **Storage:** Seagate FireCuda 520 1TB M.2 SSD, Seagate BarraCuda 4TB HDD; **Power Supply:** Corsair RM1000x 1000W; **Case:** Corsair iCue 5000D Airflow.

BLUEPRINTS

VALUE- AND PERFORMANCE-DRIVEN HYPOTHETICAL BUILDS

PC BUILDER

Budget

A perfect balance between price and peformance.

Last month, we gave the Intel budget build a slight upgrade from Core i3-10100 to Core i3-10105 with Intel's UHD Graphics 630. This month, we're going a step further by ditching the 10105 for the Core i5-10400. It's a six-core chip, so a 50 percent uptick in the core count for just $60 is a no-brainer. We're not sure how much longer 10th-Gen chips such as the 10400 will be available. So, if you fancy some cheap Intel six-core action, don't hesitate – the 10400 may not stay this affordable for long, and it could disappear altogether this year.

To recap from last issue, there were three parts that found their way into both the Intel and AMD budget systems. Due to a stock change last month, we had to change our memory around on the AMD budget build and the Intel budget build. We swapped out the Crucial Ballistix CL16 for GSkills Trident Z Neo CL 16 RAM. This is the same spec as the Crucial Ballistix RAM, so was the most suitable we could find at the price.

We've ditched the Adata Gammix PCIe Gen 4 SSD from the AMD build, as they're nearly impossible to find. In goes the far more common Corsair MP600, which adds $15 overall, but for whatever reason Adata didn't ever have much stock for the Australian market so we're sticking with the better Corsair option.

The last major change for these machines is the availability of GPUs. It is hard to recommend graphics cards that cost nearly double the MSRP, but they are there for anyone who doesn't want to wait any longer for more stock to come out. It's annoying for everyone else that this is the case, but at least there seems to be some street price stock and that's better than no stock at all.

AMD INGREDIENTS

PART		PRICE
CASE	Corsair 4000D Airflow	$130
PSU	550W Corsair CV550 80+ Bronze	$59
M/BOARD	ASRock B550 Phantom Gaming 4/ac AM4	$169
CPU	AMD Ryzen 5 3600	$349
GPU	MSI Radeon RX 6700 XT 12 GB MECH 2X **NEW**	$1,249
RAM	16GB (2x8GB) G.Skill Trident Z Neo CL 16 @ 3600MHz	$145
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0 **NEW**	$145
HDD	2TB WD Blue 7200 HDD	$80
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
PRICE		$2,386

INTEL INGREDIENTS

PART		PRICE
CASE	Corsair 4000D Airflow	$130
PSU	550W Corsair CV550 80+ Bronze	$59
M/BOARD	MSI B460M-A PRO Micro ATX LGA1200 **NEW**	$89
CPU	Intel Core i3-10400 **NEW**	$249
GPU	MSI Ventus GeForce RTX 3060 12GB	$999
RAM	16GB (2x8GB) G.Skill Trident Z Neo CL 16 @ 3600MHz	$145
SSD	500GB Samsung 980 NVME M.2 PCIe 3.0 SSD	$92
HDD	2TB WD Blue 7200 HDD	$80
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
PRICE		$1,903

PC BUILDER

Mid-range

A game-ready machine that can handle demanding work, too.

We made some big changes to the mid-range builds last time, so this month, it's minor tweaks. Inevitably, any reasonably priced GPU sells out, so both our builds have been revised. The AMD rig gets a Gigabyte GeForce RTX 3070 8 GB Gaming OC board that maintains the performance for slightly more cash. That's just the way it goes right now.

Anyway, Intel's new Alder Lake 12th-Gen chips are in the builds, specifically the i5-12600K, which is a pretty sweet CPU. It comes with 10 cores combined with Intel's new hybrid architecture. This is split into two types of cores; performance cores (six) and efficient cores (four). Foreground tasks are allocated to the performance cores while background tasks are set to the efficient cores in Intel's biggest architectural shift in a decade. The Alder Lake chips also integrate a one-click overclocking feature to the BIOS that helps users get more out of their systems. The max turbo frequency of this new chip is at 4.90GHz too.

The EVGA SuperNova GA PSU was new last month and sticks around this issue.

GPU aside, things are pretty much as they were for the AMD build apart from a few price tweaks. We've also kept the 750W EVGA SuperNova PSU for another month.

AMD INGREDIENTS

PART		PRICE
CASE	Lian Li PC-O11-Dynamic	$209
PSU	750W EVGA SuperNOVA GA 80+ Gold	$169
M/BOARD	Asus AM4 TUF Gaming X570-Plus WiFi	$270
CPU	AMD Ryzen 5 5600X	$559
COOLER	280mm Cooler Master Masterliquid ML280 RGB	$149
GPU	Gigabyte GeForce RTX 3070 8 GB Gaming OC **NEW**	$1,699
RAM	16GB (2x 8GB) Team Vulcan Z CL18 @ 3600MHz	$140
SSD	500GB Samsung 980 Pro NVME M.2 PCIe 4.0 SSD	$92
HDD	2TB WD Blue 7200 HDD	$80
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
PRICE		$3,427

INTEL INGREDIENTS

PART		PRICE
CASE	Lian Li PC-O11-Dynamic	$209
PSU	750W EVGA SuperNOVA GA 80+ Gold	$169
M/BOARD	MSI PRO Z690-A LGA1700	$379
CPU	Intel Core i5-12600K	$459
COOLER	280mm Cooler Master Masterliquid ML280 RGB	$149
GPU	Gigabyte Aorus Radeon RX 6800 XT Master 16GB GDDR6	$1,999
RAM	16GB (2 x 8GB) Corsair Vengeance RGB Pro SL RGB CL18 @ 3600MHz	$140
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0	$145
HDD	2TB WD Blue 7200 HDD	$80
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
PRICE		$3,789

PC BUILDER

Turbo

The maximum PC.

Last month, the Alder Lake Core i9-12900K chip entered our high-end build and it's likely to stay there for a while. It features a new hybrid architecture with performance and efficiency cores – 16 in total with a 50/50 split between performance and efficiency. Compared with Intel's previous top offering, the Intel Core i9-11900K, it has double the core count and eight more threads than the 11th-Gen's 16 threads.

This chip is claimed to be up to 50 percent faster than the old Rocket Lake model. Even running on DDR4, it is still the world's best gaming CPU, so we had to put it in the build. The good news is that non-GPU component pricing is now near normal, with the exception of DDR5 memory.

We introduced a Z690 board last month but with some tasty DDR5 RAM. These two additions bump the price up, as is always the case with a new generation of memory. The Corsair Vengeance sticks come in at a hefty $600, but we hope this will drop soon. DDR5 is currently in short supply, so prices and availability are volatile.

As for the motherboard, there's no change from the MSI Pro Z690-A WiFi LGA1700, an efficient board to support the new CPU and DDR5 memory. The same applies elsewhere, bar a few price tweaks, but the graphics card has changed. Out goes the Asrock OC Formula Radeon RX 6900 XT GDDR6 16GB, in comes the marginally cheaper PowerColor Red Devil RX 6900 XT Ultimate Gaming 16GB.

On the AMD side, we still can't justify the Ryzen 9 5950X at $1,099, so we stick with the Ryzen 9 5900X, albeit for a few dollars more than last month. Both machines come with Corsair's iCUE H150i Elite Capellix AIO, this 360mm cooler does a great job of keeping both of these high-performance chips cool. Also found on both setups are the same 6TB WD Blue 5400 HDDs – a great way to get a huge capacity secondary storage on both systems. The mid-range PSUs also stick around in the turbo builds. At $169, the 750W PSU offering from EVGA is hard to ignore with its 80+ Gold efficiency. ■

AMD INGREDIENTS

PART		PRICE
CASE	Phanteks Enthoo Pro 2 Tempered Glass	$210
PSU	750W EVGA SuperNova GA 80+ Gold	$169
M/BOARD	Gigabyte X570 GAMING X	$199
CPU	AMD Ryzen 7 5900X	$749
COOLER	Corsair iCUE H150i Elite Capellix AIO 360mm	$229
GPU	MSI Gaming GeForce RTX 3080 LHR 10GB **NEW**	$2,499
RAM	32GB (2x 16GB) G.Skill Ripjaws V 32GB DDR4 @ 4000MHz	$399
SSD	1TB Samsung 980 Pro M.2 PCIe 4.0	$249
HDD	6TB WD Blue 5400 HDD	$240
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
PRICE		$5,003

INTEL INGREDIENTS

PART		PRICE
CASE	Phanteks Enthoo Pro 2 Tempered Glass	$210
PSU	750W EVGA SuperNova GA 80+ Gold	$169
M/BOARD	MSI PRO Z690-A WiFi LGA1700	$240
CPU	Intel Core i9-12900K	$949
COOLER	Corsair iCUE H150i Elite Capellix AIO 360mm	$229
GPU	PowerColor Red Devil RX 6900 XT Ultimate Gaming 16GB **NEW**	$2,199
RAM	32GB (2 x 16GB) Corsair Vengeance DDR5 @ 5200MHz	$599
SSD	1TB Gigabyte Aorus Gen4 7000s M.2 PCIe 4.0	$285
HDD	6TB WD Blue 5400 HDD	$240
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$60
PRICE		$5,180

PC BUILDER MASTERCLASS

The Alder lake Machine

New-gen Intel CPU, DDR5, plus a hefty graphics card... are you as excited as we are?

The time has finally come to put Intel's latest and greatest Alder Lake chip, the Core i9-12900k, into a pretty impressive build. On the face of it, this isn't the craziest looking rig we have ever put together, but there is serious power lurking beneath the chassis.

With this build, we are hoping to showcase some of the latest introductions to the PC market. We bring in some tasty new DDR5 RAM, Intel's latest CPU offering, a hefty Geforce RTX 3080, and one of the latest Z690 boards to piece it all together. All this and more is going to make its home in one of the largest cases we have seen in quite a while – frankly, this makes an ITX build look like a Gameboy in comparison.

As we carried out our build at the end of 2021, it's a great time to showcase a few of these new introductions. Of course, the last quarter of 2021 brought us Windows 11, which will be the chosen OS for this machine. Combined with new DDR5 and Intel's latest Core i9-12900k processor, it makes for cutting edge stuff.

While we are always excited to try the latest offerings, it's not all sunshine and lollipops. For a start, the cost of a new chip, memory, and GPU will certainly leave a gaping hole in your wallet. We know everyone wants the latest tech but is it worth investing at the start of a new generation of goodies, or is it better to wait a while for the prices to drop?

This build might help you to decide. So, let's see what we can get out of this thing.

Sam Lewis

ALDER LAKE INGREDIENTS

PART		PRICE
CPU	Intel Core i9-12900K	$920
GPU	Asus ROG Strix GeForce RTX 3080 10GB	$2,700
RAM	32GB (2x16GB) Corsair DDR5-5200	$650
MOBO	Asus ROG Strix Z690-E Gaming WIFI ATX	$800
OS STORAGE	2TB WD_Black SN750 M.2 PCIe 4.0 SSD	$420
PSU	Nzxt C850 80+Gold PSU	$180
COOLER	Corsair iCue H170i Elite Capellix AIO	$325
CASE	Corsair 7000D Airflow	$325
TOTAL		$6,320

CPU $920

INTEL CORE I9-12900K

Branded as the world's best gaming CPU on launch, this is a bold new hybrid step for Intel's architecture. With 16 cores split equally, eight foreground performance cores, and eight background efficiency cores, it aims for the best of both worlds. The i9-12900K sits at the top of the Alder Lake family boasting a frequency of up to 5.2GHz with one-click overclocking. It's everything we could want in a showcase build. **intel.com**

MOTHERBOARD $800

ASUS ROG STRIX Z690-E GAMING WIFI ATX

Following the traditional ATX format, this board from Asus is one of the best to pair with some DDR5 and Intel's strongest Alder Lake chip right now. With support for 12th-Gen Intel, PCIe 5.0, 5 M.2 heatsink slots, and great gaming connectivity, it should be a strong board to keep everything under control. **asus.com**

MEMORY $650

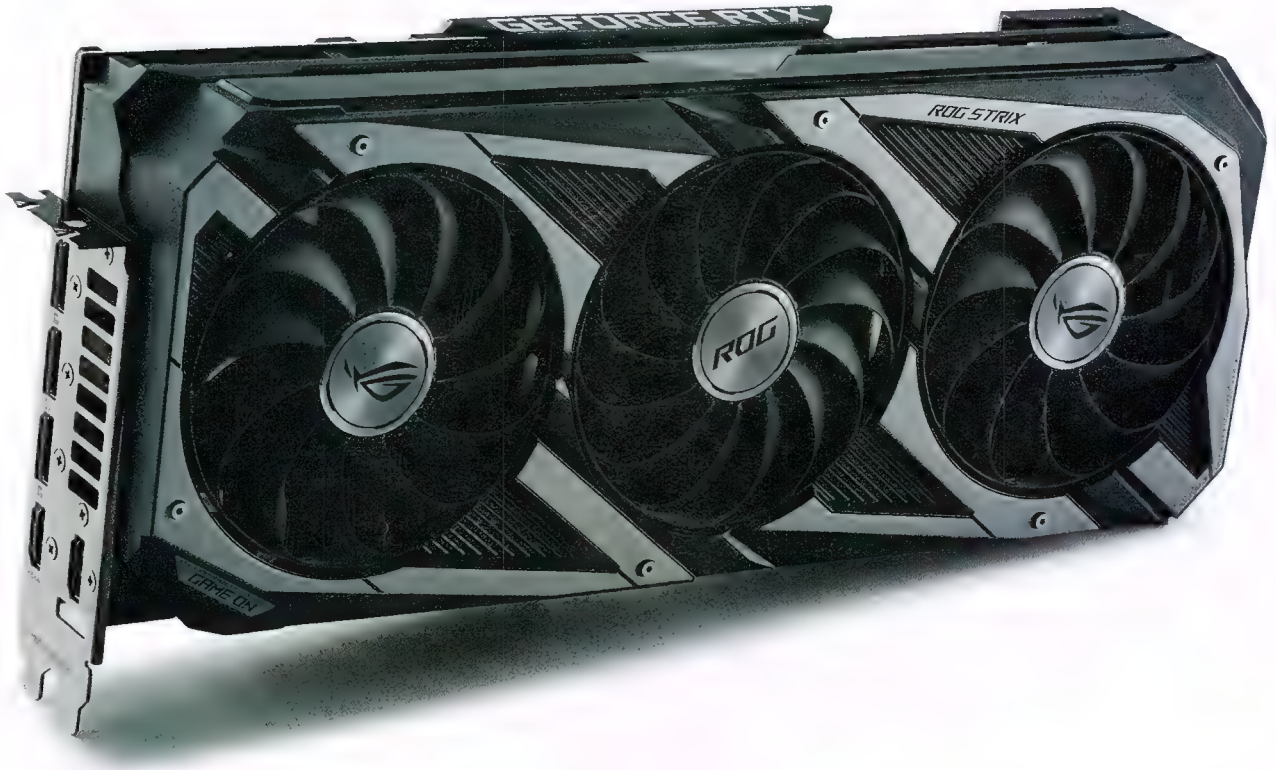
32GB (2X16GB) CORSAIR DDR5-5200

Sure, it's hard to visually differentiate it from the previous DDR4 DIMM sticks, but it's the underpinnings and potential that push this generation of memory in a positive direction. With a speed of up to 5,200MHz and a solid 2x 16GB configuration, this specific RAM makes a great addition to the build. **corsair.com**

GPU $2,700

ASUS ROG STRIX GEFORCE RTX 3080 10GB

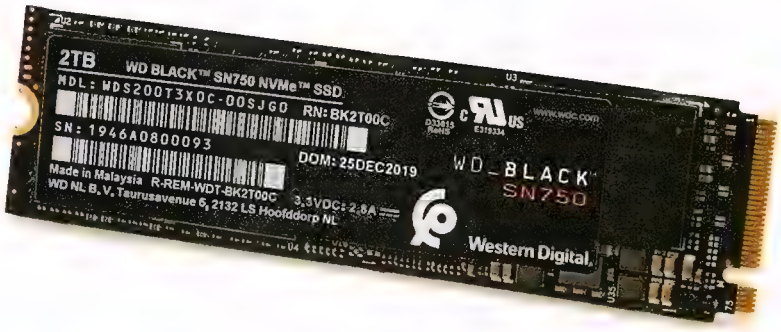
This is a pretty pricey GPU, but aren't they all these days? The sad reality is to get one of the best GPUs, you'll have to pay a pretty penny. With price markups currently so high, it's hard to recommend these high-end GPUs at the moment, although the performance is exactly what you'd hope it would be. To get the most out of this rig, we needed a super strong GPU and Asus's offering here is a great match for our build. **Asus.com**



STORAGE $420

WD BLACK SN750 M.2 PCIE 4.0 SSD

When it comes to storage, Western Digital provides some of the best pieces of hardware around. 2TB of storage is plenty even though we don't have secondary storage in this build. Although it's not the latest SSD, it's still an incredibly dependable piece of storage with nippy speeds. We opted for the variant without heatsink as the Z690 board was providing that. **westerndigital.com**



CASE $325

CORSAIR 7000D AIRFLOW

One word comes to mind when we take a look at this case, and that's behemoth. We wouldn't be surprised if you could enclose a whole other build (case included) inside this thing. Due to its large mass, it makes for great accessibility and loads of airflow, hence the name. The ability to mount seven 140mm fans here should keep this hot build nice and cool. Anyway, the construction is superb – if it didn't weigh so much, it would probably take off with those seven fans – and its sheer presence is begging for us to put something pretty special underneath. **corsair.com**

PSU $180

NZXT C850 80+GOLD PSU

This machine is sure to use a decent amount of power, regardless of the fact that half of the new i9-12900k is made of efficiency cores. Nzxt's PSU not only delivers 850W of power but also the peace of mind that you have covered the demands of this machine. With support for GPUs up to RTX 3090, it should be more than enough for our 3080. The modular design means we can use exactly what cables we need to keep things as tidy as possible. **nzxt.com**

CPU COOLER $325

CORSAIR ICUE H170I ELITE CAPELLIX AIO

To make the most out of this enormous case, we also need an equally huge AIO to keep things nice and cool. The iCue H170i Elite Capellix from Corsair was a great match for our case and should do a solid job of keeping the internals nice and cool, especially the 12th-Gen Intel processor. It has three RGB fans to keep the front all sparkly and has a massive 420mm radiator. **corsair.com**

A NEW GENERATION

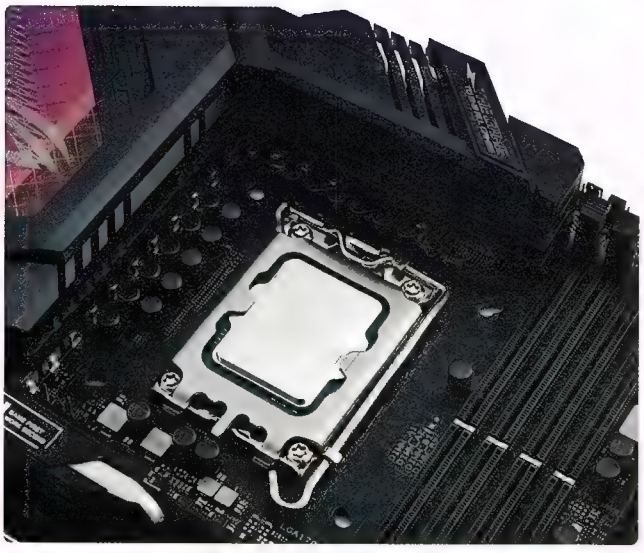
IT'S GOOD ON PAPER. BUT HOW WILL THIS 'NEW GEN' SYSTEM ACTUALLY PERFORM?

01 Case opening

Here it stands, all tall and proud. We've said it before, but this is one huge battleship. The 7000D Airflow is an impressive feat from Corsair and feels as rugged as ever. Yes, it's pricey. But the build quality and size lends itself to this type of price tag. It features great accessibility with tidy cable management solutions around the back. There are also plenty of panels that pop off to allow for easier cable routing. We also love the wing-style side panel doors, reminiscent of a supercar. For a showcase build, we think it fits the profile nicely. First though, we pop open the wing-style panels and take off the front panel.

02 Motherboard prep

Before we dive straight into this one and pop the motherboard into the case, we first need to prep it for the CPU. It's also much easier to attach all the necessary parts to the board before installing it. Yes, there is a lot of room around the board with this case but it's a good habit to work out the case first. Before we touch the CPU, we remove the plastic piece under the CPU latch. You don't actually need to do this, as it will pop out when you secure it down anyway, but it works either way. To open the latch, lift the retention arm up slowly out of its catch. Push it down initially and to the right to release it. Easy-peasy.



03 Alder Lake install

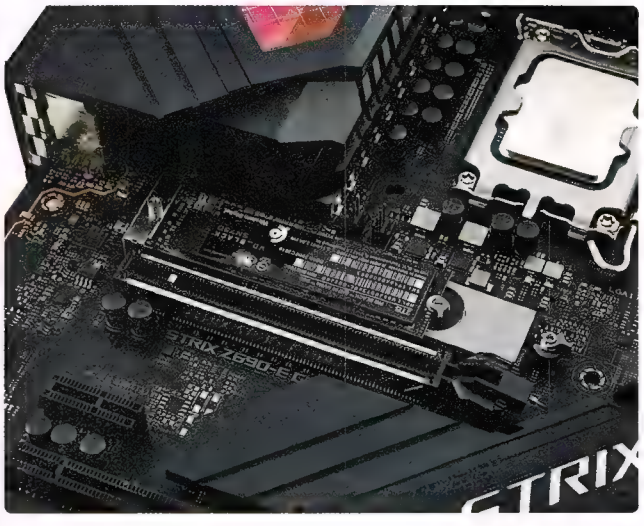
Not only does Intel's new processor bring a vast amount of architectural and generational changes but it also features a new socket, the LGA 1700, found on our Z690-E board from Asus. Thankfully, this doesn't alter how we insert the CPU. Align the two triangles from the processor and the socket to make sure it's going in the right way. Then by grabbing the sides gently, rest it down into place, making sure not to touch any of the pins underneath. Once it is seated correctly, we pull the retention arm back down towards the latch and tuck it in to lock it in place.

04 DDR5 time

Just as the design hasn't changed all that much from DDR4 to DDR5, nor has the installation process, which is a good thing. Installing the DIMM sticks is one of the easiest parts of building a PC and gives us a little bit of time to relax in the build. Before installing, we always refer back to the motherboard's manual if we are using fewer than the full amount of possible DIMM slots. As we have only two sticks of DDR5 to use, we need to use the correct slots and this turns out to be slots 2 and 4. After identifying the correct slots, we push back the RAM tabs on the board and make sure the pins are aligned with the slots. Once happy, we push them in and they click nicely into place.

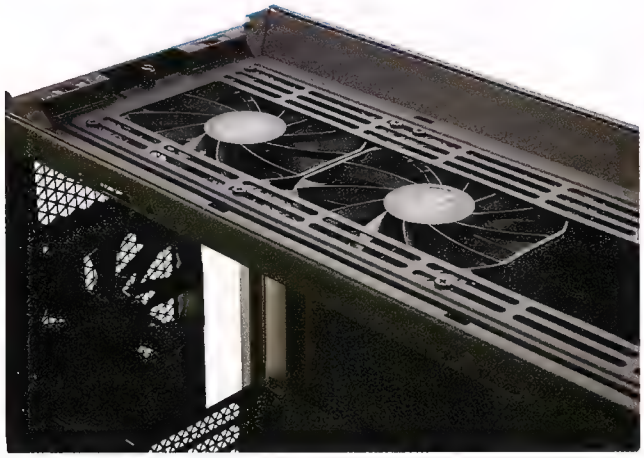
05 Heatsink woes

If only it was as simple as just popping in the SSD. We love the way this board looks, so wanted to keep this look without removing any heatsinks. Unfortunately, we had to do this as our first SSD came with a heatsink itself. Note that we said 'first' – this SSD wouldn't fit with the motherboard's covers on top. Initially, we unscrewed the bottom SSD heatsink cover. This was one big long cover that has two slots underneath, one for a conventionally sized SSD, and the other could fit another and also a longer SSD. The problem is that if we use one side, the other side is exposed with the heatsink film, making the board look pretty ugly.



06 SSD success

We didn't want to have an exposed empty M.2 slot, so we decided to use the top M.2 slot just under the CPU, which is technically a better slot. Again though, with the cover on top, this wouldn't fit over our WD Black SSD due to its heatsink. Thankfully, the stars aligned perfectly as we happen to have the exact same SSD without a pre-installed heatsink lying around in our studio. We unscrew the top heatsink cover and slot in our SSD at a 30° angle to the port. Then, we secure it with the plastic screw covers that came with the board. After a few mishaps and then a little bit of luck on our part, the 2TB SSD from Western Digital was secured.

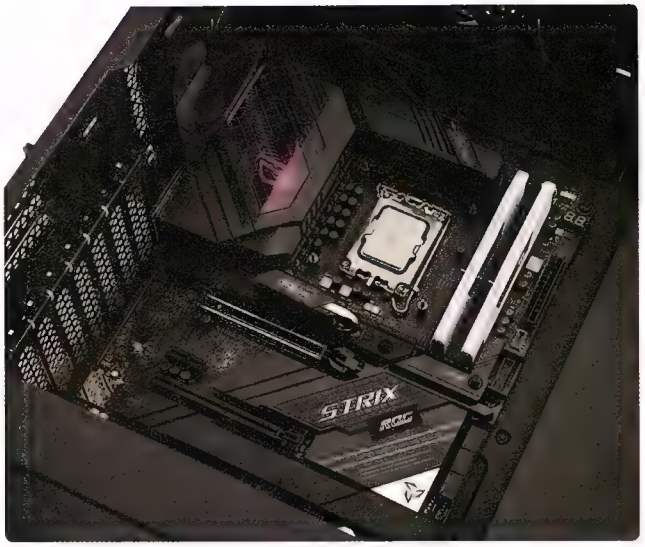


05 Fan relocation

So that we could fit in our AIO later on with the Corsair RGB fans from that kit at the front of the case, we had to remove the front two fans. This leaves us with only one other place to put them, at the top. As all of our front three fans will be pulling in air through the case, and the other case fan at the back is already set up as an exhaust fan, we decided to use these as exhaust fans too. Remember, when it comes to fans, faces suck. This means we need to have the faces of the fans pointing towards the inside of the case in order to pull the hot air away from the motherboard. Each fan is connected with four Phillips screws and is super easy to detach and re-attach. Just make sure to route the cable through the back of the case and also ensure that it's long enough to reach the commander core fan controller.

07 Cooling time

With the CPU cooler bracket and mobo securely in place, it's time to install our radiator and fans. As we moved the stock case fans earlier, we could fit the three Corsair RGB fans at the front of the case that came with our H170i Elite Capellix AIO. Holding the radiator in place, we attach our first top fan making sure the fan cables feed to the back of the case. We also make sure that the radiator pipes come out of the topside of the radiator for better circulation. It can be fiddly to get the first few screws in place as they feed through the front of the fans, the frame on the case, and then into the radiator but, after this, everything should align nicely. To keep the airflow pulling in from the front, we have the faces facing outwards.



06 CPU cooler bracket and motherboard

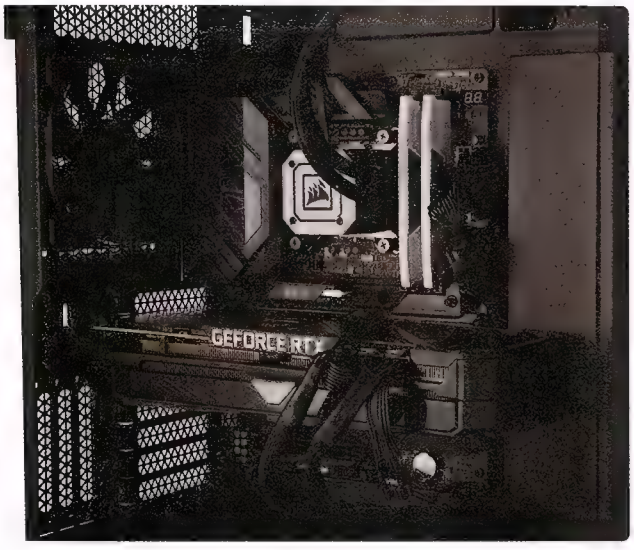
Before we installed our motherboard into the case, we take both the winged panels off to lay the system down. After that, we attach the CPU cooler bracket for the AIO pump. This is an easy job, but make sure you choose the correct bracket, in our case the Intel one, and the correct standoffs. For this board and CPU, we use the Intel 115x/1200 standoffs. The bracket slots in behind the CPU at the back of the motherboard. Once aligned, screw the standoffs in place at the front of the board. Now it's time to install the mobo. It didn't need an I/O shield to be added first, so it's an easy installation. First, we angle the I/O plate into the slot in the case and gently rest it flat in place. Using eight screws, we fasten it onto the board, starting with the corners then the middle screws. And, just like that, the board is in.

08 CPU header

After the fans and the radiator are sorted, it's time to add the rest of our AIO into the build, the CPU header. This also needs the correct Intel bracket on it to fit, which it already did, thankfully. The first thing to do though is to add a pea-sized drop of thermal paste onto the center of our Intel i9-12900K CPU. To fit properly, it has to be in the correct orientation with the radiator pipes coming out of the right-hand side. Once oriented and thermal paste applied, we carefully align the CPU header onto the CPU and secure it down with the supplied thumbscrews. Slightly tightening diagonally to get even pressure across the CPU. Once happy, we use a screwdriver to tighten some more, then connect the CPU fan cable straight to the motherboard.

09 Adding the GPU

Now, this is always a pretty nice addition to the build and by the size of this 3080 from Asus, we are glad we chose this huge 7000D Airflow case to fit it in. To add this into our case, we first have to take off two of the small backplates from the back of the case. We don't need to take the top one off just the two below it to make room for our GPU ports. Then we push down the PCIe tab which is similar to the tabs holding the RAM sticks in place. First, make sure the port section of the GPU goes in at an angle so it fits in with the case, then make sure it clips in place to the PCIe slot. We choose the top slot as this is the primary PCIe port.



11 Connecting the dots

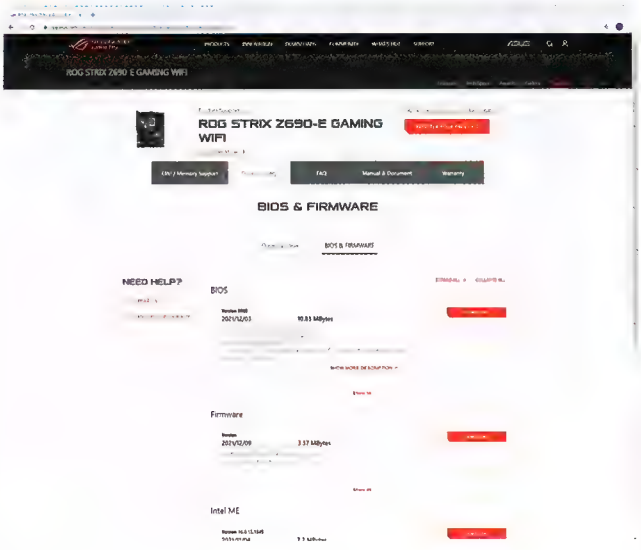
So at this point, we have every component in place but it's no good without connecting up the veins of the PC. Start by connecting up the front panel cables – check the motherboard's manual to locate where these go. This stage can be fiddly, but there is plenty of room in this case and it is a quicker process than normal. After this, we attach the PSU cables to the motherboard first, then route them through the back and to the PSU. This includes PCIe cables for the GPU, the 24-pin motherboard cable, two CPU cables, and one SATA. We connect the SATA to the commander core fan controller and then the fan and RGB cables up to the controller. Nothing was too much of a squeeze to fit in, just awkward and precise, but when isn't it?

10 Supplying the power

The last hardware component to go in is our Nzxt C850 PSU. This is a modular design, so we could easily install this with no cables getting in our way (yet). The PSU slots right in the bottom of our case and secures into place with four screws. This adds even more weight into the already hefty build, so we're glad we only had to pick this up and transport it once. Don't try lifting this build on your own, aside from the aches that will follow, you don't want any chance of dropping this monster, that doesn't even bear thinking about.

12 Tidying up

Technically that's it for our build. It was pretty successful on the whole, hardware-wise anyway. Before we head over to the software side of things, we need to do a bit of cable management and get this PC paneled up. We don't often recommend cable managing to a permanent level until the end and until we know everything is powering on at least. So, we flick the switch, and thankfully, our build begins to spark into life. Throughout the build, we recommend keeping cable management in mind by routing cables to the best place possible. At this stage, we just need to tuck things out the way or use the cable ties. Thankfully, this case has some good cable management routing solutions, which we follow, and in areas where we create our own paths, we use the cable ties to neaten things up. After this, we pop on the panels once again, give it a quick wipe to get rid of any fingerprints, and our PC is built.



13 Preparing BIOS update

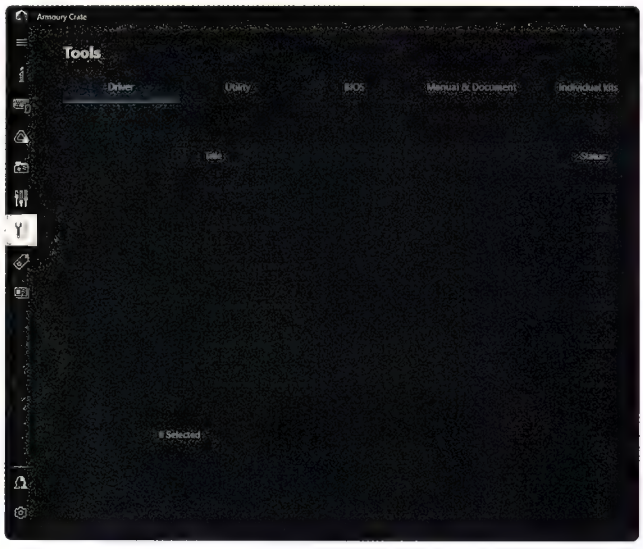
Once the build is complete, we hook it up to a monitor ready to boot it up. However, we need to update the BIOS first in order to move forward. For this method, we are using a USB drive and another system to perform the BIOS FLBK (flashback) method. We head over to the motherboard's support page and download the latest BIOS update to the USB drive. Make sure the drive is empty and formatted correctly to FAT32. The download will consist of a CAP file and a renamer tool. First, we extract the folder then run this tool afterward to rename the CAP file. Then we delete everything on the drive, apart from the newly renamed CAP file.

14 Installing BIOS update

Make sure that your new system is off but with power running to the machine and with the PSU switch turned on. Then insert your USB stick with the BIOS update into the port in the back of the PC labeled BIOS FLBK, this should have a button directly above it and a white line distinguishing it from the other USB ports. Then, hold down the BIOS button for at least three seconds or until you start seeing a green flashing light and let go. After around 10 seconds, this light should start flashing faster. It will continue until the BIOS has been updated, don't turn off the power in the meantime. Once the light has stopped, boot up your system and the BIOS should hopefully be updated. Now it's ready to install Windows 11.

15 Windows 11

Using another system, search for 'Windows 11 media creation tool' and click on the first link to the official Microsoft website. Click on the second option 'Create Windows 11 Installation Media' and download. For this step, you need a clean USB drive of at least 8GB formatted to FAT32. If using the one for the BIOS, make sure to wipe it first. Once downloaded, run the program, and when it gives you the option to choose which media to use, select USB and then the specific drive. This will download a bootable version of Windows 11 to the USB drive. Insert it into your PC, turn the system on, and head to the BIOS by mashing the 'delete' key on startup. In the 'boot' section, change to boot from a USB stick, hit F10 to save and exit. Your system should restart and run through the installation process.



16 Updates, drivers, first software

By this stage in the build, everything has been put together and we now have Windows 11 running smoothly. However, the PC still needs a few more tweaks to get things properly up and running. First off, we connect it up to the internet and update our Asus Armory Crate, which is an all-in-one utility for Asus boards. This has all the necessary drivers to install, plus the chipset for our Intel CPU. With these installed, we headed over to the Windows Update section in the settings just to double-check everything is up to date there too. The final thing we need to do is head over to ninite.com and download our first few pieces of software. Ninite is a great all-in-one solution where you can find all the necessary applications in one place.

1 Even in this huge case, the Asus ROG Strix RTX 3080 is a monstrous GPU and performs just as well as it looks. In an ideal world, we would try and swap this out for a 3090 but it was hard enough in the first place to get a 3080.

2 To match the lighting with the front of the case, we'd love to replace the stock fans with some of the same fans from our AIO. This should hopefully spruce up the interior of the can a little too.

3 Although we have plenty of RAM in this machine, there is nothing wrong with adding a little more. Four DIMM sticks will look better in this chassis – with only two, it can look a little lonely.

4 Annoyingly on our GPU, there is a loose PCIe cable from the PSU cables that came with our Nzxt C850. Next time around, some aftermarket cable solution would sort this solution and look a lot neater around the whole machine.

Next gen futureproof?

So here we are, the machine's all built, everything fits together (eventually), and everything works (at last). Yes, we did have some teething issues. On first boot up, we couldn't get through the Windows 11 installation without it crashing. In fact, the error was to do with the CPU cooler and our CPU was briefly hitting around 88° under practically zero load.

That almost left us quaking in our boots, but thankfully it was a simple error. After a bit of cable management, we managed to dislodge the main commander core fan controller cable. Unfortunately, we didn't figure this out until we removed the CPU cooler and reinstalled it with some new thermal paste. Better safe than sorry.

Other than this issue and our little mishap with the heatsink SSD situation, it was fairly smooth sailing for our Alder Lake system build. The Corsair 7000D Airflow case was easy to work in, mainly due to the sheer amount of space we had. Usually fitting the CPU cables from the PSU to the motherboard can be a pain in the rear end but, for once, it was a quick process with plenty of room to fit the bend of the cable in. The only issue was moving this rig around – when fully built, it's one hell of a heavy unit.

The performance of this machine was great and what we expected. Intel's Extreme Tuning Utility allowed our CPU to run from 4.90GHz to 5.10GHz all from some easy one-click tuning. With sliders cranked all the way to the right, this PC runs super nice and quiet. Thanks to the huge 420mm radiator, six 140mm fans, and plenty of space available in this case, temperatures are great even when this is under full load.

Of course, at an MSRP of over $6,000, it costs a pretty penny. At this price, you expect it to run the numbers it does on the benchmarking. But is it worth investing in now? Probably not. You're better off waiting a while for these prices to fall – with every generational change, they always start off sky-high. However, this is certainly a clean, future-proof build in a monstrous case that has tons of presence. ■

	Zero-point	Alder Lake
Cinebench R15 Multi-Thread (index)	2,413	4,189
CrystalDisk 0321 Sequential Read (MB/s)	2,721	5,544
CrystalDisk 0321 Sequential Write (MB/s)	2,769	2,938
Tom Clancy's Ghost Recon: Wildlands (fps)	62	84
Total War: Warhammer II (fps)	75	98
Rise of the Tomb Raider (fps)	103	78
3DMark: Fire Strike (index)	26,706	37,817

Our zero-point conists of an Intel Core i9-11900K, 16GB (2x8GB) Corsair Vengence RGB PRO DDR4 @3600, an MSI GeForce RTX 3070 Gaming X TRIO and a 1TB Samsung 970 Evo Plus M.2 PCIe 3.0 SSD. All game tests are performed at 3840 x 1600 at the highest graphical profile.

Quick Tips

The problem solvers

The *APC* team field problems across the spectrum of devices and software. Learn a new trick or fix you can use.

PCIe 4.0 glitch

I've been building PCs since the first 386 I put together, so I'm no stranger to PC problems. I recently bought a new computer from CyberPowerPC rather than build my own, thanks to the video card situation. I had three Seagate external drives connected to my old computer – two 3.5-inch drives with their own PSUs, and a USB-powered Backup Plus Portable. I connected all three to the USB ports directly on my MSI MPG X570 Gaming Plus motherboard. I had no problems with the two larger drives, but the portable drive kept disconnecting every few minutes. In Event Viewer, the System logs were filled with errors for that drive.

I didn't think the drive could go bad just plugging it into a new computer, so I updated the motherboard BIOS and all the drivers. Nothing helped. I chatted online with Seagate support and CyberPowerPC. They both had the usual suggestions – try a different cable, plug it into a different USB port, none of which worked. I submitted an RMA to replace the drive and while waiting for the new drive to arrive, I plugged it into the front USB port, which connects to the JUSB4 header on the motherboard. Astonishingly, the drive didn't experience any more problems (I still don't know why this port worked).

I searched the internet for any problems related to my motherboard and, to my surprise, I found out that AMD has a USB connectivity problem with its X570 chipset. When it is set to use PCIe 4.0, that appears to affect all motherboards using this chipset, not just my MSI. This problem has existed for around a year from what I've seen and there's still no fix. I have a Ryzen 5700G, which only supports PCIe 3.0, so I just changed the BIOS setting to use PCIe 3.0 and I've had no further problems. But that's not a permanent fix if I ever want to upgrade the CPU or my M.2 drive. But the support people I chatted with had no knowledge of it and AMD doesn't have a fix.

Kevin Mahoney

***APC* Responds:** First, thanks for sharing your detailed troubleshooting process and subsequent discovery. AMD acknowledged the problem back in February and released an AGESA firmware update (1.2.0.2) for Ryzen 5000-series CPUs that allegedly fixed the problem – but not for all. Interestingly, subsequent updates have been rolled out, your X570 board had two subsequent patches (1.2.0.3b and 1.2.0.3c) via BIOS updates but, in your case, clearly to no effect.

APC can't provide a definitive explanation as to why the front-mounted port proved more stable for your external self-powered USB drive. The front-mounted ports connect through the X570 chipset rather than directly to the AMD CPU (its four dedicated ports are on the back of your motherboard), so would be subject to the same problems with PCIe, given that the X570 chipset interfaces with the AMD CPU through a PCIe uplink/downlink.

That said, some confirm the issue specifically manifests itself with USB 2.0 ports, which might explain why shifting the drive to the JUSB4 port (USB 3.2 Gen1 according to your motherboard specs) got it to behave properly, but that assumes you hadn't tried rear-mounted USB 3.2 ports while troubleshooting.

However, the fact you've found a port you can use may mean you'll be able to upgrade your hardware and re-enable PCIe 4.0 at a later date, although you may then subsequently experience issues with other peripherals, specifically audio devices, connected via USB 2.0 ports.

Other workarounds reported by users that you could try include bumping the SoC voltage up and minimizing power saving for PCIe. Type 'power plan' into the Search box and click 'Edit a power plan'. Click 'Change advanced power settings' and expand 'PCI Express > Link State Power Management' and change the setting to 'Off' to see what effect that has.

One final suggestion is to open Device Manager after updating the BIOS and drivers, navigate to the Universal Serial Bus controllers section, then remove all USB controllers and hubs before rebooting to allow them to add themselves back automatically.

100 percent CPU usage

I've been following the magazine for a couple of years now, and have started to try my hand at buying used PC parts, building a system, and flipping it for profit. I recently built a modest gaming system with an AMD A10 9700 and a GTX 960 2GB (which I found for a great deal considering today's GPU prices) along with 8GB of DDR4, but I've encountered an issue with the CPU reaching consistent 100 percent usage in games and even just on the desktop for some reason.

Obviously, this is an older system, but I have a nagging feeling there's more to it. I suspect issues with the AMD chipset driver or Windows power settings, but what are your thoughts?

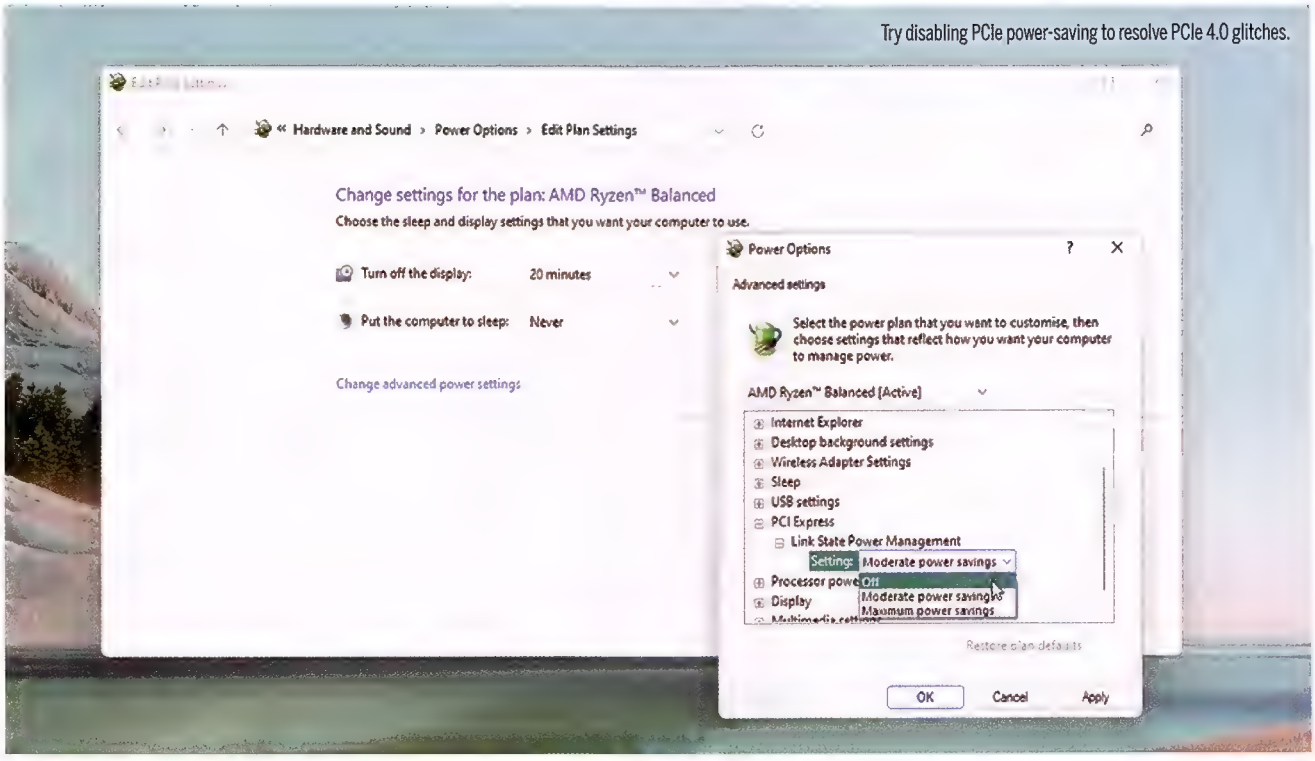
Gavin Jones

***APC* Responds:** We suspect the key issue here is your hardware spec: the A10 is six-year-old tech that has been massively outclassed by today's CPUs. Indeed, it's currently comparable to the Pentium Silver J5040, a fanless, SoC designed for low-powered servers. With that in mind, it's going to struggle with the increased demands placed on today's ultra-fast processors by both Windows and applications alike.

Hardware upgrades that will help alleviate these problems include more RAM (aim for a minimum of 16GB for multi-tasking) and a fast SSD boot drive. That said, it's worth seeing if you can identify specific processes or applications that may be taking more than their fair share of system resources to exacerbate the problem.

The next time it happens, open Task Manager, go to the Processes tab, and click the CPU column once to show the most intensive processes at the top of the screen. Focus your troubleshooting on whatever processes are taking up available CPU resources, for example, is the Windows Search Index constantly running in the background?

If you're unable to target a specific culprit, or you find it's a case of too many applications struggling to rein in their demands, you might have to look at a tool like Process Lasso (**https://bitsum.com/**), which is designed to balance heavy loads on underpowered machines by reining in


« Hardware and Sound › Power Options › Edit Plan Settings
Change settings for the plan: AMD Ryzen™ Balanced
Choose the sleep and display settings that you want your computer to use.
Turn off the display: 20 minutes
Put the computer to sleep: Never
Change advanced power settings
Power Options
Advanced settings
Select the power plan that you want to customise, then choose settings that reflect how you want your computer to manage power.
AMD Ryzen™ Balanced (Active)
Internet Explorer
Desktop background settings
Wireless Adapter Settings
Sleep
USB settings
PCI Express
Link State Power Management
Setting: Moderate power savings
Off
Moderate power savings
Maximum power savings
Display
Restore plan defaults
OK
Cancel
Apply
Try disabling PCIe power-saving to resolve PCIe 4.0 glitches.

processes making excessive demands.

The free version provides all the key balancing functionality you need, but upgrade to the Pro version and you'll be able to set up profiles and exercise fine-tuned control over specific processes.

Password manager

Hope I'm not being a pest, but I have another request. I've been using KeePass Password Safe v1.71 for more years than I can recall. It's a simple encrypted basic database of all my account passwords and usernames, along with their URL and a comment box for notes.

It still works fine for my needs, but only supports Internet Explorer. The problem is that lately when I click an account's URL, the URL opens in Internet Explorer and I often get a message that the site doesn't support IE and wants me to switch to a different browser.

I have been searching for a new password manager, but I can't find one that works similarly to KeePass. I want one that keeps everything on my local PC, not in the cloud. Free would be great, but I don't mind having to pay a one-time fee – monthly or yearly subscriptions are out of the question.

I know I'm being picky, but the only issue I have with KeePass is that it just supports IE.

If my only options are to go to the cloud or pay for a subscription, I'll just keep this outdated KeePass and then switch browsers when necessary.

Steve Vanetti

***APC* Responds:** It sounds like you're relying on the KeeForm plugin to allow you to open websites automatically from KeePass, and this only works with Internet Explorer.

Given that KeePass development has stalled of late, you might want to look at a KeePass-compatible fork such as KeePassXC (**https://keepassxc.org**). This boasts a more modern look and feel, and can import your current KeePass 1.x database and convert it into the 2.x format. It also comes with a range of free browser extensions that enable you to easily access your passwords from within your browser.

If you're looking to move completely away from KeePass, perhaps to a tool that can be used with your mobile devices as well as your PC, then check out Buttercup (**https://buttercup.pw/**). Again, your passwords are stored offline in a secure database, but you can also install browser extensions and mobile apps (iOS and Android) to gain access to your passwords on the go in the same way as a cloud-based solution such as Bitwarden.

Block Win11 update

What can I do to prevent Windows Update from upgrading to Windows 11? I recently bought a new laptop that will support Windows 11, but I don't want to do that upgrade until all the bugs are sorted out and resolved, and most of those missing Win10 features are added back in.

I found a Registry hack on How To Geek (**www.howtogeek.com/765377/how-to-block-the-windows-11-update-from-installing-on-windows-10/**) but am hoping for something that does not require going into the Registry.

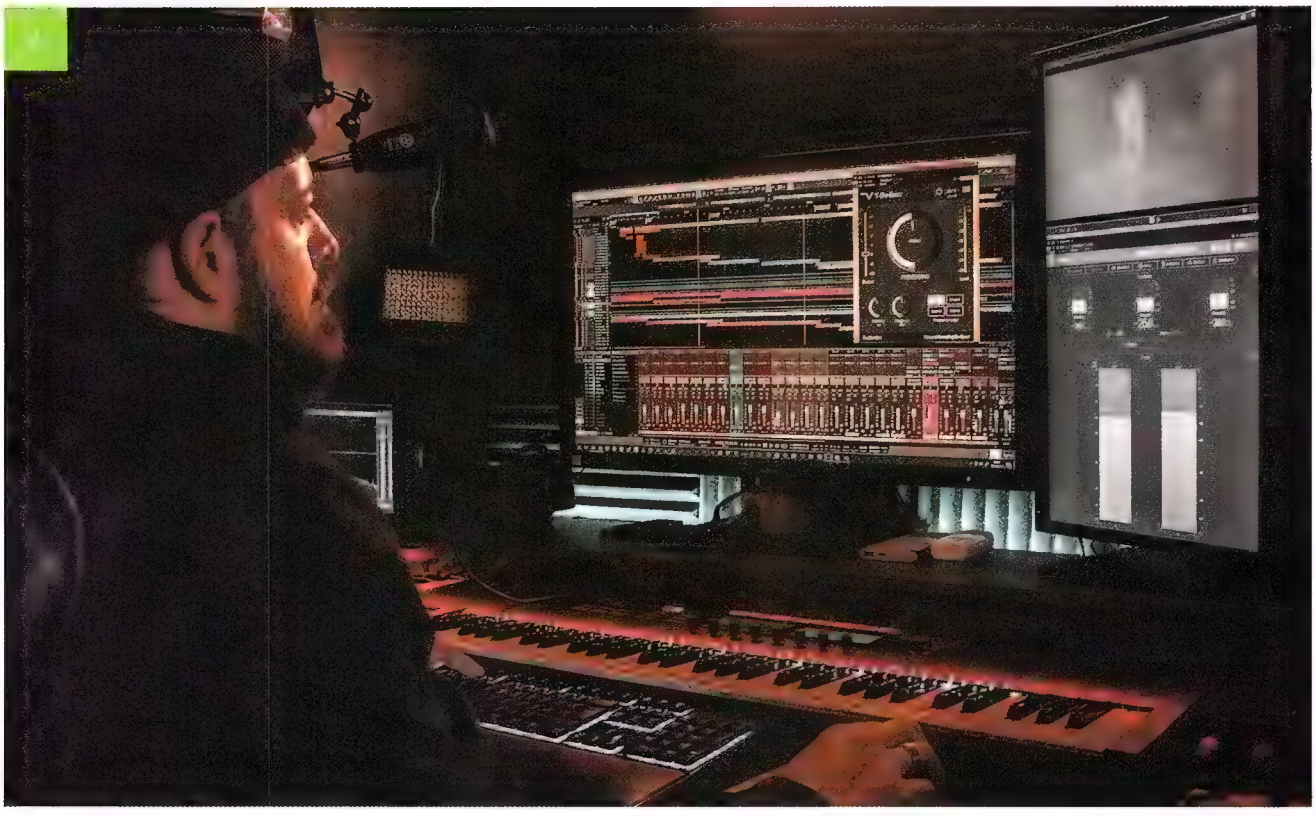
I've turned off Secure Boot and disabled the TPM, but am skeptical about that working. The BIOS has an option to 'Hide' the TPM, but I am also skeptical about that. I have made an external image of the drive a couple of times, but it is too small to allow for frequent internal backups (once it is out of warranty, I will fix that).

Dave Marshall

***APC* Responds:** However insistent its prompts may be, there's no way Windows 11 is going to force itself on you before you're ready to upgrade, Dave. Unless Microsoft breaks all known conventions, it can't switch the TPM on in your BIOS or enable Secure Boot without your say-so.

If Microsoft has determined that your laptop isn't compatible – and it technically isn't without Secure Boot or the TPM enabled – then it shouldn't keep nagging you to update it. The only feature updates you should be seeing will be the latest Windows 10 (21H2) update, which obviously is safe to install at this point.

Dave confirmed that he wasn't being prompted to update having disabled Secure Boot – he plans to revisit Windows 11 next year, at which point, he will then need to re-enable the TPM and Secure Boot to receive Microsoft's invite to install it. ■



WINDOWS

YOU'LL NEED
Windows 8.1, 10 or 11, At least 4GB RAM, at least 4GB free disk space

Stepping into music production

Learn the evolution of digital music production, and how you can do it today, with Sam Lewis.

Over the past decade, the way we listen to music has fundamentally changed. No longer tied to physical forms, such as vinyl discs, cassettes, or CDs, downloading and streaming services have taken music collections away from our shelves and placed them on our desktops.

The rise of digital audio is largely responsible for this change. Products such as the original Sony Walkman and the Apple iPod delivered music on the go, but these were eventually superseded by the smartphone, which can now deliver many thousands of music tracks all day, every day, from your rucksack or pocket, making music more accessible than ever.

The same can be said for music production. Whereas once you needed a band or an orchestra of musicians playing instruments, studio time, and expensive recording equipment, these days it is possible to produce a song, publish it, and listen to it from the comfort of your desktop. With a smartphone and software, you can even do this from the palm of your hand.

Here, we will take a look at how music production has changed over the years, the software you need to get started, and how you can compose your own musical masterpiece.

The dawn of the digital audio age

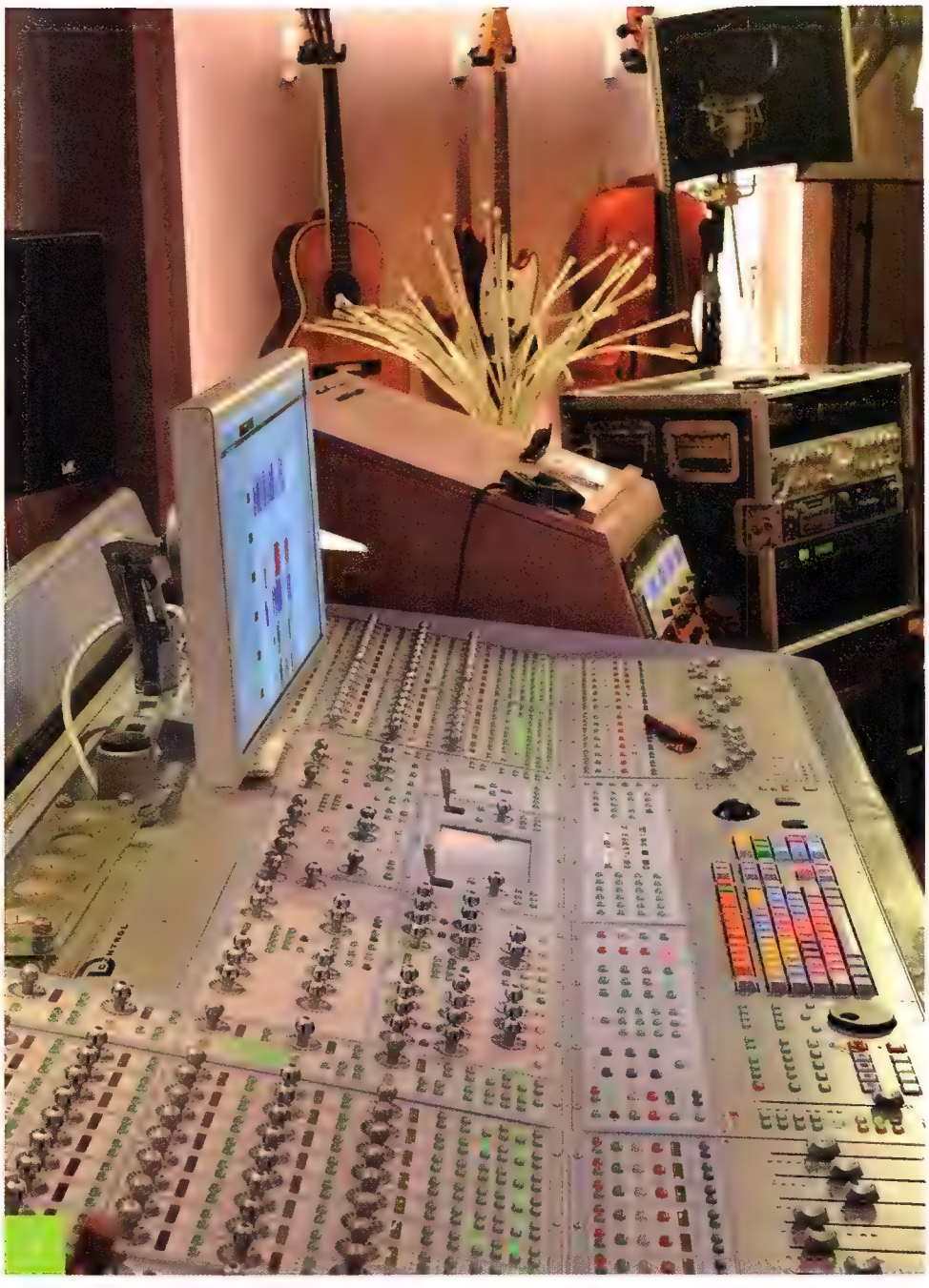
Before we go any further (well, backward technically) we first need to understand the fundamental elements of the digital audio workstation (DAW). Pretty much most music you hear these days will have been composed or produced in some way with the help of a DAW. Thanks to its ease of use, format, efficiency, and productivity, this technology has superseded most other traditional methods of music production. When it's this easy to produce music, it just makes sense to go down the route of DAWs.

So then what is it? A DAW is a piece of software that lets you manipulate audio recordings in a multitude of different ways. A DAW lets you record audio, loop, compose, sample, edit, master, mix, and more. You can use it to create music, master audio for video production, commercials, YouTube videos, you name it **[Image A]**. The possibilities are endless.

In its simplest form, a song is simply a layering of sounds in a specific order. A DAW lets you control the layering and allows you to choose the order of sounds.

To understand how DAWs came to be, we will take a step back to the mid-1970s. Newly formed, and later to be industry giants, Soundstream made a huge mark on the audio world. Based in Salt Lake City, Utah, the company was one of the first digital audio recorders in the USA. It played a massive role in developing digital audio recording, editing, and producing, despite competition from rival 'audiophile' companies.

The mark Soundstream left behind still influences audio production to this day. For producers of the time, the introduction to a more digital style of work was a huge technological change to their workflow and the whole industry. The tools that came



with the shift to digital production were groundbreaking at the time and paved the way for audio production to come.

Soundstream was founded by Dr. Thomas G. Stockham Jr. in May 1975 at the University of Utah. Stockham wanted a solution to the issues he was having with analog audio at the time. He essentially wanted the ability to remove distortion, background noises, and general unwanted sounds that could creep into recordings, but in a more efficient way.

In 1962, Thomas, using a TX-0 computer and an 'analog-to-digital' converter, began creating digital audio tape recordings whilst studying at MIT (Massachusetts Institute of Technology). As digital audio is binary data, when it's transferred to tape it isn't subject to the issues Thomas was facing with traditional analog audio, such as the distortion he was encountering.

By the late 1960s in Japan, engineers at the NHK television broadcasting network had created a fully working stereo recorder featuring two channels. This had a sampling rate of 32kHz and 13-bit resolution.

At the start of the 70s, Japanese audio company Denon had used this recorder to produce the song Something by Steve Marcus. This was the first digitally-recorded, commercially-released track. Denon then created the DN-023R, an eight-channel recorder with the same 13-bit resolution but a larger sampling rate of 47.25kHz.

By 1975, Stockham had begun working on Soundstream's first digital audio recorder prototype by designing the architecture for the device. His team consisted of electrical engineers and computer scientists that helped spark this idea into life. Jules Bloomenthal joined as a technician in September that year, and he helped build a computer interface for the machine. This would allow for the transfer of digital audio data in real-time between a computer and a recorder.

The machine contained an instrumentation tape drive by Honeywell that was commercially available at the time. There was also an analog-to-digital and digital-to-analog ('A-D/D-A') converter and tape encoding and decoding electronics inside too. A Digital Equipment Corporation PDP-11/60 computer was used for the editing with this machine.

The digital audio was stored on two RP04 disk drives that were connected to this computer. The computer would then run Soundstream's software called 'DAP', which stands for digital audio processor. This could perform basic edits, such as cross-fades and splicing by using a text terminal. This machine was the precursor for modern DAWs and the principle has stayed true to this day, just with a bit more convenience.

The problem at the time, and for the ensuing years, was making this commercial. The process required large amounts of fast storage and, back then, this was quite the struggle.

By the end of the 1980s, the technology was evolving at a rapid rate and the popularity of home computers such as the Apple Macintosh, Commodore Amiga, and Atari meant that storage concerns were less of an issue. Companies such as Digidesign and Macromedia began developing applications that could edit audio samples and perform two-track CD mastering.

In 1994, four-track editors came along, this saw companies such as Pro Tools, and the first Windows-based DAWs come into life. By 1996, 32-track DAWs were readily available and year after year they continued to get more detailed, faster, and more capable, becoming the industry standard recording system **[Image B]**.

DAWs have given the ability to allow anyone to produce and create music and it's thanks to the initial development from companies such as Soundstream that allowed this to happen.

The components

Of course, you will need either a PC or a laptop to run your DAW and hook all of your equipment up. It isn't necessary to have a crazy, powerful machine that runs ridiculous numbers, however, the faster the PC **[Image C]**, the more processing it will be able to handle. You will soon realise that your music composition

projects can get pretty intensive.

For FL Studio, the minimum requirements for the Windows application are; Windows 8.1 and above, at least 4GB of free disk space, and 4GB of RAM. On the FL Studio website, it states that 'the more powerful your CPU, the more instruments and effects you can use – and they aren't wrong.

DAW

We have already spoken about DAWs, but choosing a good one is essential to you feeling confident when producing music or any form of audio. So what is the best DAW to choose to start with? It's hard to give a definitive answer to this question, as with many applications, it takes some trial and error to find the one you like.

All DAWs will provide you with enough tools to create a similar end goal **[Image D]**. The good thing about the majority of them is that they will provide you with either a demo or a free trial to test them out. We recommend picking one with a clean interface as heading into a new piece of software can be pretty overwhelming. Also, this is where the real estate from a dual monitor setup or an ultra-widescreen will come in handy.

To make life a little easier when starting and to keep organised, you want as little clutter as possible. Interface-wise, we recommend trying FL Studio to get into the world of audio production. It has a colourful, clean, and intuitive UI that should help inspire some creativity.

Studio reference headphones/ monitors

Hearing the most accurate and purest version of your project is the best way to get the most honest result. Using studio reference devices can allow you to distinguish details that other peripherals may not pick up, so you can tweak to even deeper depths.

Although the term 'studio' is often thrown around lightly, true studio headphones or speakers still hold value. They are created with the intention of being used in the recording studio or your home office. We recommend opting for headphones first as they are often the more affordable option **[Image E]**.

True studio headphones shouldn't leak sound when recording. If you are singing/playing an instrument whilst listening to a guide to follow along with, the last thing you want is for the microphone to pick up any headphone leakage. These will most likely be a closed-back design.

Of course, you also want them to be comfortable and durable if you are using them for long periods. However, the most important factor here is the sound quality. Studio headphones are designed to reveal flaws in your recordings and generally deliver a more neutral flat soundscape for this reason.

MIDI controller

MIDI stands for musical instrument digital interface and a MIDI controller **[Image F]** essentially connects physical hardware to the software. This can be used to virtually play instruments and sequence audio files on your DAW.

You can use this device for pretty much anything, it works as a universal controller that will play whatever you tell the DAW to play. For instance, you could load one button or key on the MIDI to play a specific drumbeat.

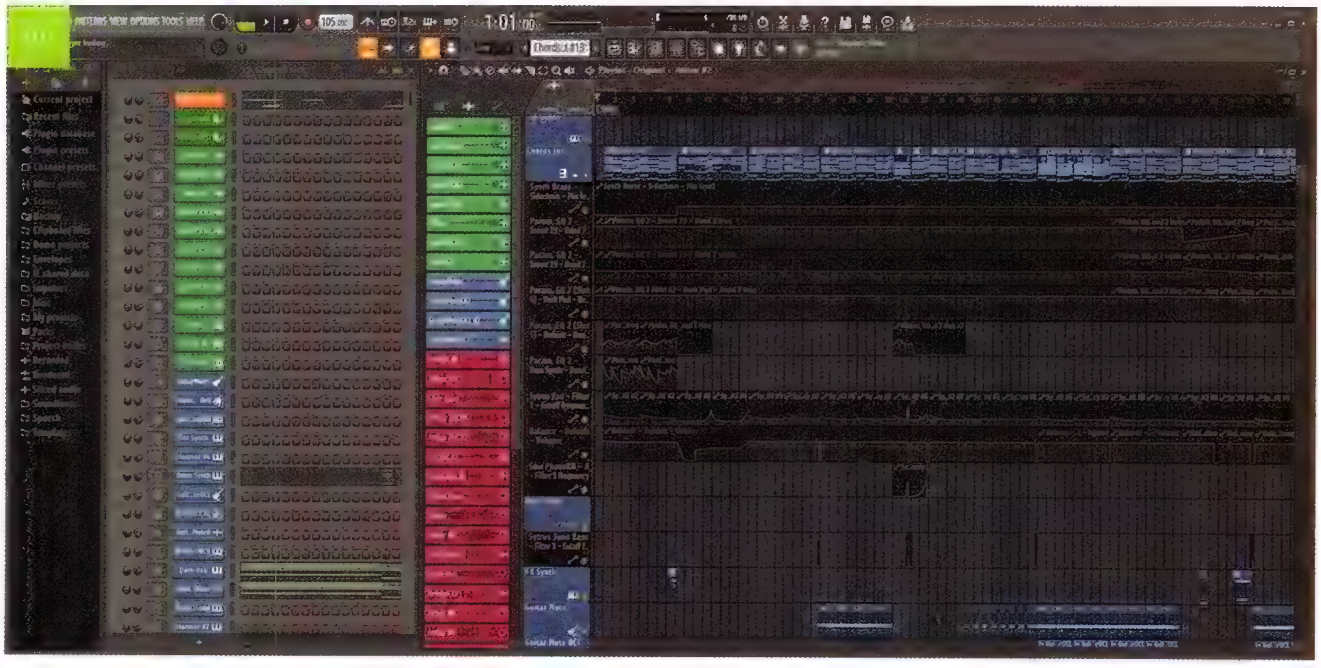
A MIDI makes workflow incredibly efficient because of how flexible it is. Typically, they feature keys, a drum pad, and some dials.

If you decide to purchase a MIDI controller, AKAI produces some great introductory mini-models that should get your creative juices flowing.

FL Studio 20 introduction

In this mini-tutorial, we will look at the main segments of the FL Studio DAW and how to get started when creating an audio project. This should give you an understanding of how this application works, its layout, and its functionality. Hopefully, by the end, you'll be able to have a crack at your own project and see if you can piece together a basic production.

On the face of it, this may look a little



scary, but when you break it down, it should help you feel at ease with this DAW and others. Songs are constructed by layering different sounds on top of each other and putting them all together. Think of it as a cake, with the layers providing a well-rounded taste.

To get to grips with FL Studio, we start with a blank canvas. There are four essential elements of this software that are the fundamental building blocks.

Browser

On a standard layout of FL studio, the browser can be found on the left-hand side of the UI **[Image G]**. This is where the sounds, instruments, and samples are going to be stored for your projects. It is well organised and easy to navigate around, which helps with efficiency. Like most projects, clear organisation is key to a good workflow.

To find a drum beat sound, you can head into the pack's menu, then drums and you will have an array of pre-installed samples to choose from. You can always add your own recordings into your work and use the browser tab to locate them. To do this, head up to options in the top tab, file settings. Then in the 'browse extra search folders' pop-out window click on a folder icon to find the folder you want to bring into your project.

Channel rack

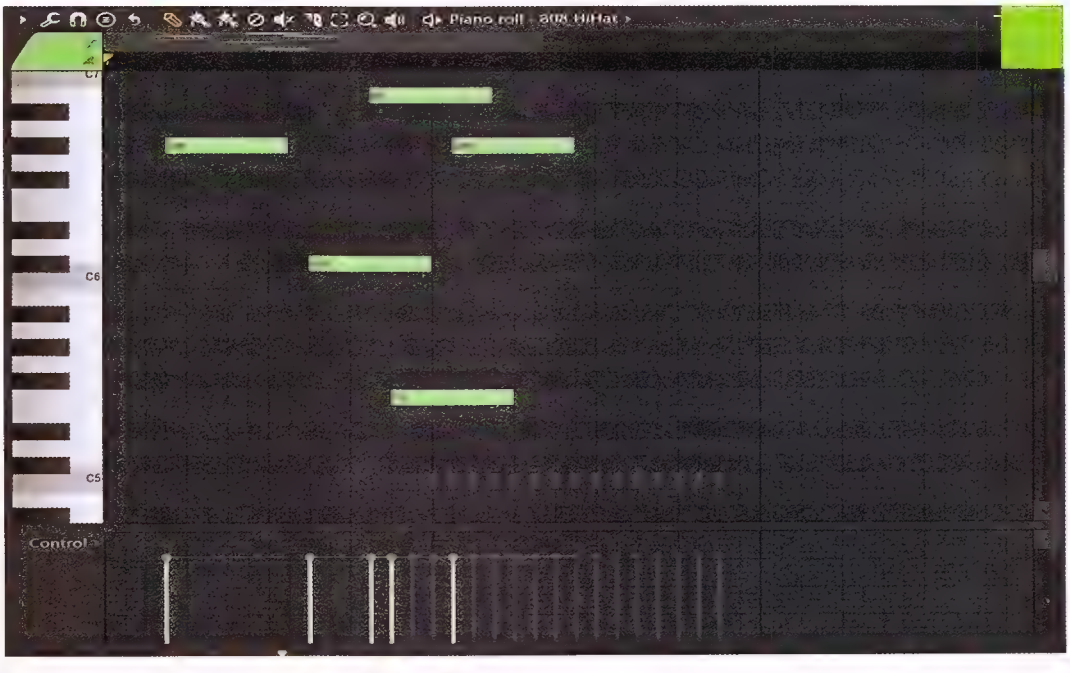
Once you have found a sample you are happy with, simply click and drag this over to the channel rack window.

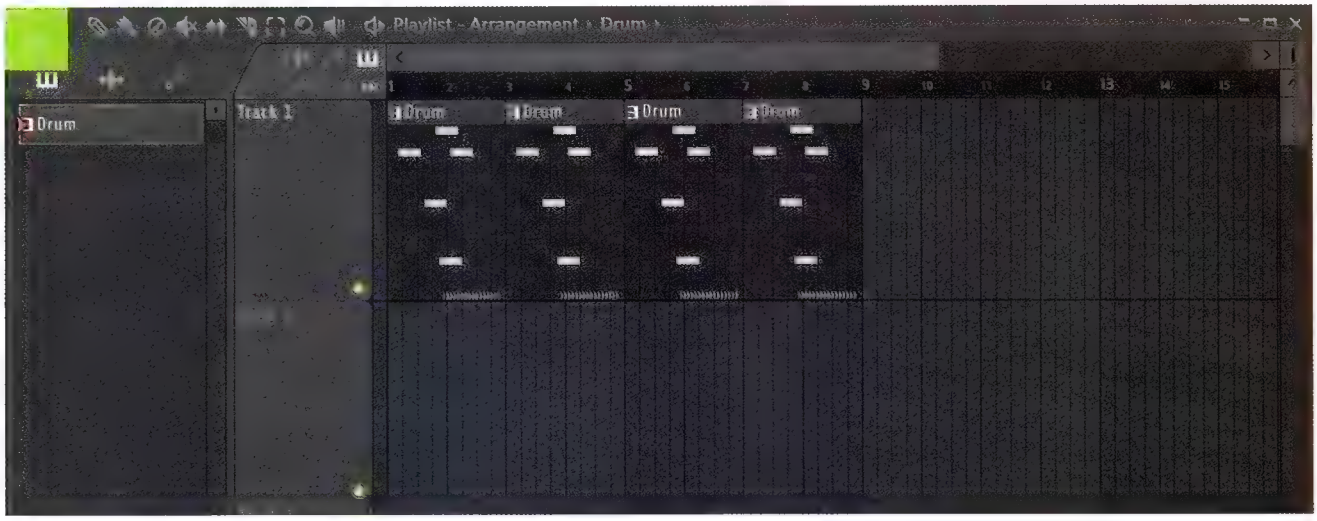
Thankfully in FL Studio, everything is named clearly, which helps with efficiency.

The channel rack is one of the most important windows in this DAW and is where all your channels are kept. If you click on a channel name in the channel rack, it will open up another window in which you can fine-tune your sample. Some of these tunings include stretching, pitching, reversing, crossfading, and more.

Each channel has a green button next to it. When you click on this, it will mute the specific channel **[Image H]**. Next to the green button are two dials, the first for panning and the second for volume. To remove a channel from the rack simply right-click, then delete. The numbers on each row relate to the mixer channel that the sample is being sent to.

Finally, next to the name in the channel is the 16-step sequencer, indicated by a row of tiny rectangle icons. This is an easy way to create a loop, click some of these sequences then hit the spacebar to hear your loop play





through. At the top of your screen on the left of the play and stop icons are buttons for pattern and song. Whatever is clicked is whatever will play, make sure the 'pat' button is selected to hear your loops.

Experiment by bringing different sounds into the channel rack, using multiple channels and various sequences to create a simple beat.

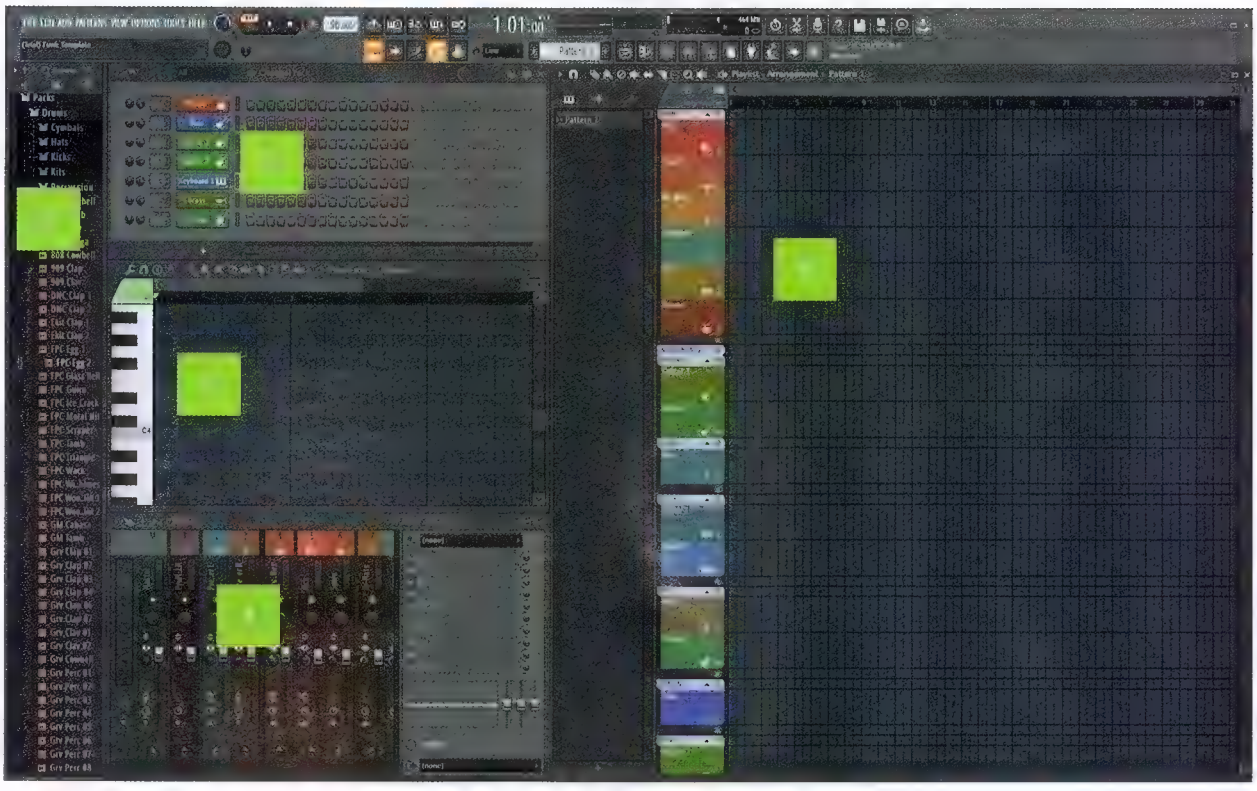
Piano roll

In this section, you can take the channel notes and go into a lot more detail. Here, you can compose and edit MIDI notes from a channel. MIDI is a software language that allows your computer, a MIDI controller, and other instruments to communicate with each other. When creating audio on a MIDI controller, it can be easily manipulated at a later date if you make a mistake. Whereas if you hit the wrong string on a guitar whilst recording, chances are you may have to re-record a whole piece of the music.

To open up the piano roll, right-click on any channel name in the channel rack and click 'piano roll' from the list. Now we can create melodies by left-clicking to add notes and right-clicking to remove them. To change the duration of the notes, drag on the edge to shorten or lengthen **[Image I]**.

You can also drag notes around to put them precisely in place. Keep pressing the spacebar to play through the pattern you have created, it should loop this sequence.

At the top, there are tools such as the slice tool to chop up notes, the mute tool, and the rectangle tool that allows you to select multiple notes at once. At this stage, try experimenting and see if you can come up with a fun little MIDI sequence of your own to create a melody.



FL STUDIO 20 USER INTERFACE

01 Browser
This is the place to find samples, beats, instruments, and your imports.

02 Channel rack
The channel rack holds all of your chosen instruments and is where you can make loops and sequences.

03 Piano roll
Use the piano roll to create unique sequences. You can also connect your MIDI controller to this to play an endless array of instruments.

04 Playlist window
This is where you piece together all the elements of the song to create a finished track. It works in a similar way to the piano roll.

05 Mixer
All audio in FL Studio passes through the mixer, this is where you can alter the quality and levels of the audio signal.

Playlist window

Hopefully, at this stage, we now know how to create basic drum patterns in the channel rack and MIDI melodies in the piano roll. The playlist window **[Image J]** is where you bring the elements together to create a complete track. This is where the layering of the patterns you create will be orchestrated.

To listen to what this window sounds like, we need to head back up to the top and select the 'song' button instead of the 'pat' button next to the play and stop function. So now we will be taking what we have created and applying it to the playlist window, similar to how we created layers in the piano roll.

Click in the track 1 row and draw out the pattern four times. Then to listen, hit the spacebar to hear this sequence. We were testing too, don't slate us for our purely experimental patterns. To help with organisation and pattern naming, in the channel rack press the F2 key to rename a pattern. This will help you when things start to get messy.

As we mentioned earlier, songs are made of layers. We have our drums (kind of) so to add a new layer, press the '+' icon next to where your pattern name is in the top window bar. This will create a blank new pattern and you will notice that the channel rack is now empty.

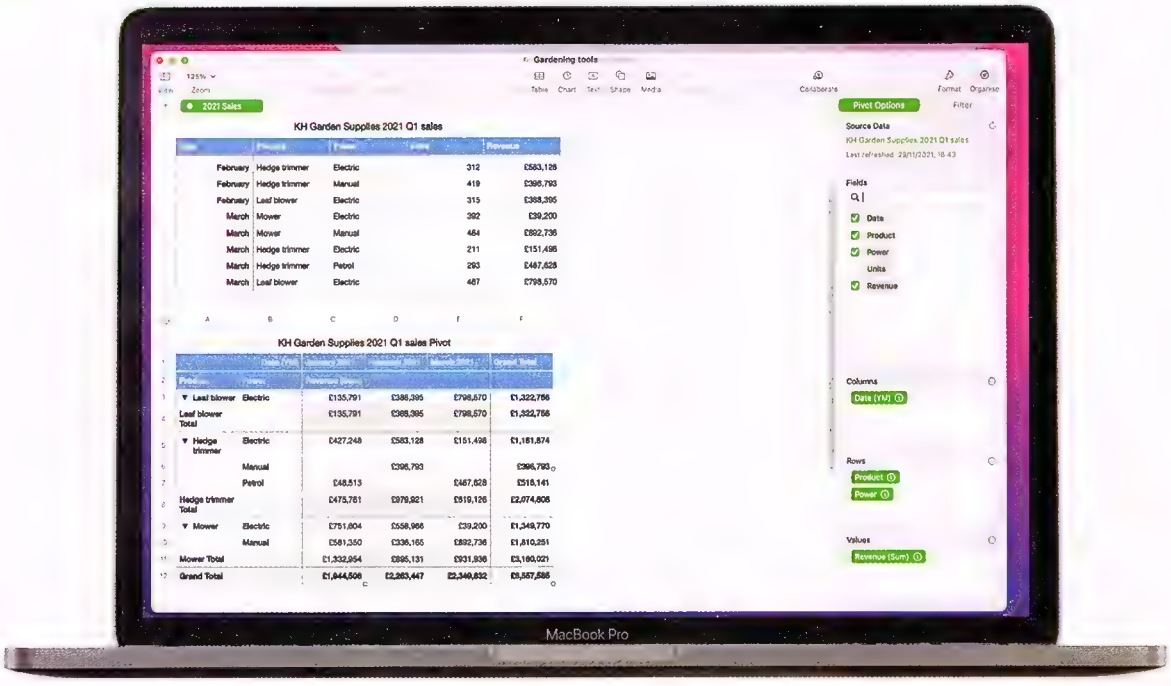
Here we can add in a new 'sound', for example, a guitar riff or piano keys. This is where you will start to layer your song. You can also drag audio files straight from the browser to the playlist window to add them directly if no tweaking is needed.

The arrangement will be done in the playlist window, but the construction of the riffs and melodies is created in the channel rack and piano roll. Music production certainly isn't a quick and easy thing to do.

The key is to have fun with what you are doing and to keep practicing over and over again – experimenting with layering different sounds together, mixing samples, and splicing instruments together until you have some form of song at the end.

This guide might not help you become a successful music producer overnight, it's simply a basic overview of how the main sections of a DAW work, in this case, FL Studio 20. If you are serious about learning to compose digital music, you could do some research on music theory before diving right in to get an understanding of how songs are written. There are a plethora of videos and tutorials online about how to construct basic melodies and rhythms, and piece together all the elements to create a track.

Once you get used to how these applications work, with some practice and a bit of patience, you should be able to compose a basic tune. ■



APPLE MAC

Data analysis in Numbers

Numbers' newest feature – pivot tables – is a powerful data analysis tool.

IT WILL TAKE
45 minutes

YOU WILL LEARN
How to use pivot tables in Numbers

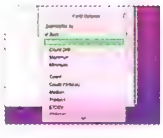
YOU'LL NEED
Numbers 11.2 or later

While Numbers surpasses Microsoft's Excel in some areas, it is lacking in others. Excel, ahem, excels at slicing and dicing data and allowing you to build scenarios. While Numbers doesn't… until now that is.

The most recent version of Numbers on Mac, iOS and iPadOS supports pivot tables. And in case you don't spend your days knee-deep in spreadsheets, pivot tables are tables that allow you to 'pivot' data from another table. So, if for example, you have a table that records widgets sales, you might have columns for the type of widget, date sold, price they sold for, quantity and sales office responsible. Each row would be one sale. You could then create a pivot table to show how many of each widget had been sold. Or how many widgets had been sold by each office.

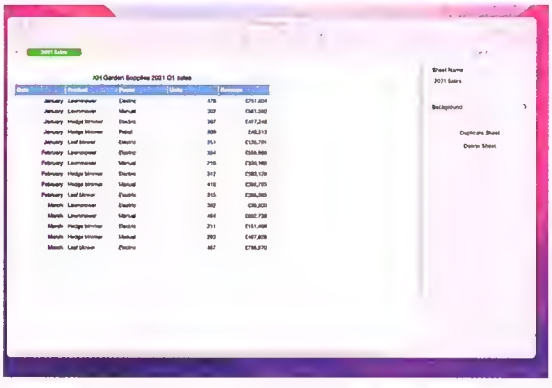
Numbers is pretty smart, and if you put the date of a transaction against a sale and create a pivot table to group sales by date, it will put all the sales for each month together.

Kenny Hemphill



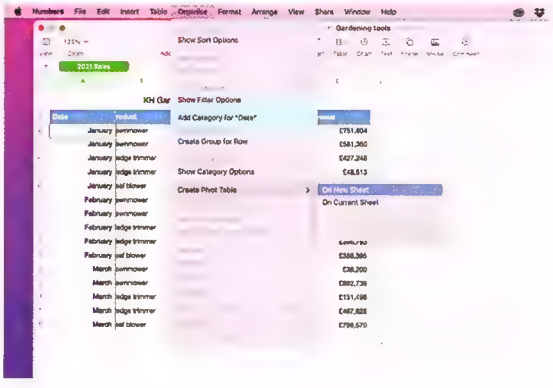
GENIUS TIP!
The values field defaults to summing the values in the data type, but you can make it show the average, the number of records, the maximum, or minimum.

HOW TO Create pivot tables in Numbers



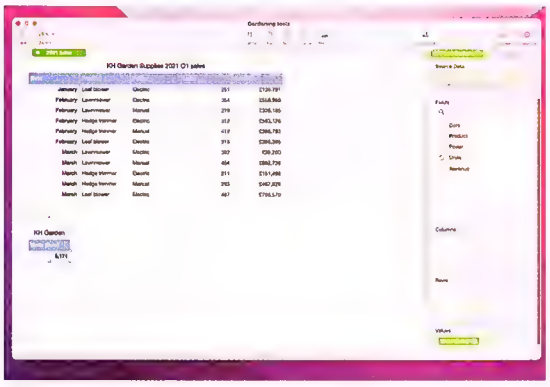
01 Choose your data

Before you create a pivot table, you need a table to work from. For this tutorial, we're going to use a simple table that records sales of different gardening tools from a wholesaler. The table holds basic info about each sale.



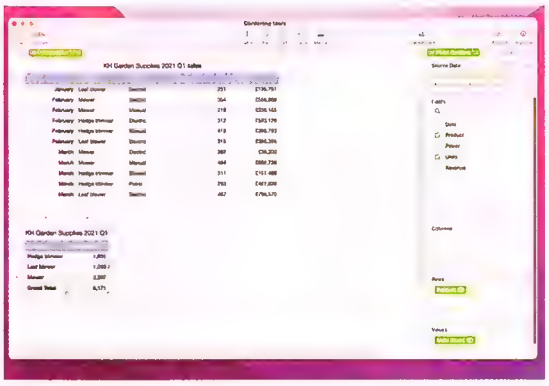
02 Create the first pivot

The easiest way to create a pivot table is to click the Pivot button in the tool bar. This will put the pivot table on a separate tab, so to keep it on the same tab, choose Organise > Create Pivot Table > On Current Sheet.



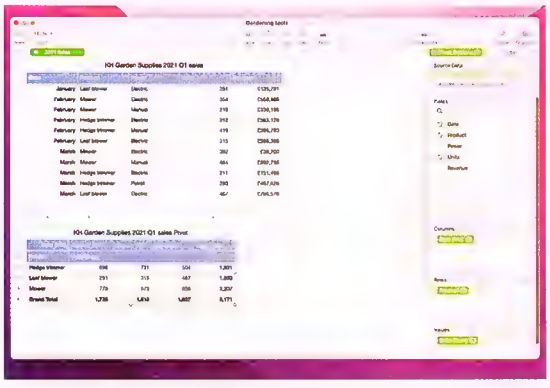
03 Sort your data

You'll see an empty table appear on the sheet and, in the right-hand sidebar, Pivot Options. To start with, choose one field. We've chosen Units. Check that box and the table is populated with the total number of units sold.



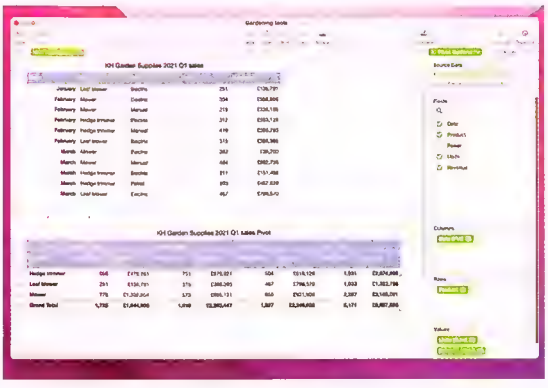
04 Add another field

Knowing only the total units sold isn't that helpful, so here we'll add another field. Check the box next to Product, and you'll see the units are now split by product, so we can see how many of each product we sold.



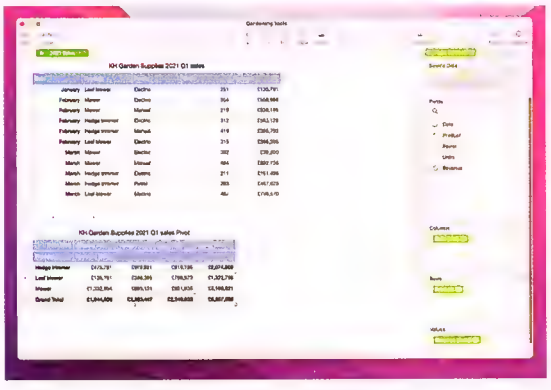
05 Dig down deeper

We're beginning to see how useful pivot tables are. But we can do more. Check the box next to Date and you'll see the months added as columns. We can now see how many of each unit was sold in each month.



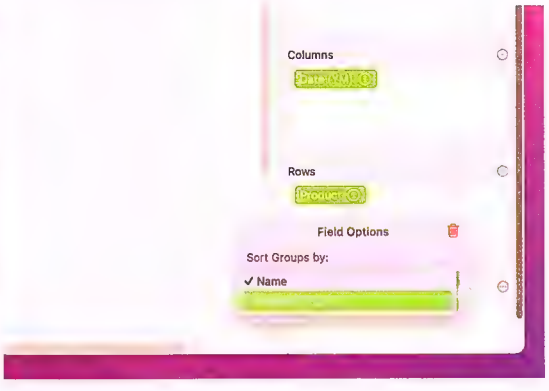
06 Switch to revenue

Unit sales is a useful metric, but what if we want to know revenue instead? Check the box next to Revenue and Numbers is smart enough to put it in the Values section. We can now see the units sold and the revenue.



07 Simplify your table

It's getting busy, so let's delete the units so we're only left with revenue. Select Units in the Values section and press the Delete key. You can do this for any field, plus drag and drop fields from one place to another.



08 Sort differently

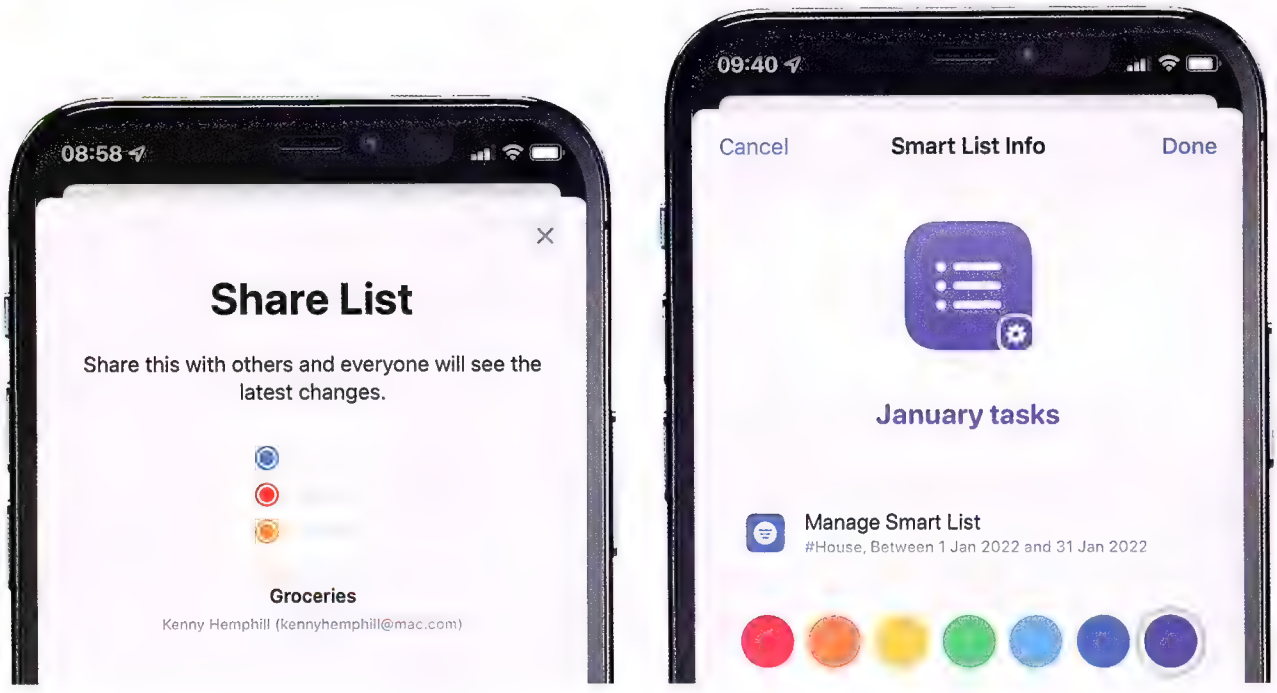
The rows in our table are ordered alphabetically by product name. To order them by revenue, click on the 'i' next to the Product field name and choose Revenue from the menu. Choose Ascending or Descending. ■

JARGON BUSTER

A **field** is a set of data values of the same data type in a table. So, in our example, fields include date, units, product and revenue.

GENIUS TIP!

When grouping values by date, Numbers defaults to month and year, but you can customise it to, say, quarter and year, or week number and year.



APPLE iOS

Assign tasks in Reminders

Use Reminders as a tool to delegate tasks to friends, family, and colleagues.

IT WILL TAKE
30 minutes

YOU WILL LEARN
How to assign tasks in Reminders

YOU'LL NEED
iOS 13 or later

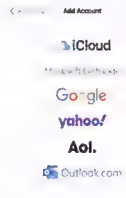
Recent iOS updates have meant some great improvements to Reminders. The app has gained lots of new features, including the ability to collaborate with others on tasks. You can invite others to share lists you create and then, once they have accepted, you can assign reminders to them. You can also assign reminders to yourself. When reminders are assigned to you, Reminders creates a Smart List called Assigned to You so you can see them all in one place.

Custom Smart Lists are new in iOS 15 and they make it easy to keep track of reminders. They allow you to organise reminders based on parameters you specify such as time, location, flag, or priority and we'll show you how to create them. We'll also show you how to use tags, another recent addition, to make finding reminders even easier.

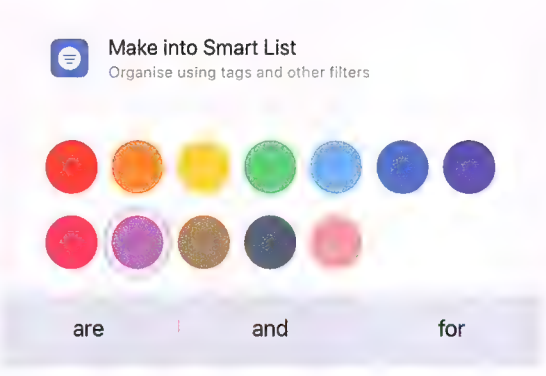
When you create a reminder in iOS 15, Siri suggestions will prompt you with the names of people it thinks you might want to share it with or which tags to add

Kenny Hemphill

HOW TO Delegate reminder tasks

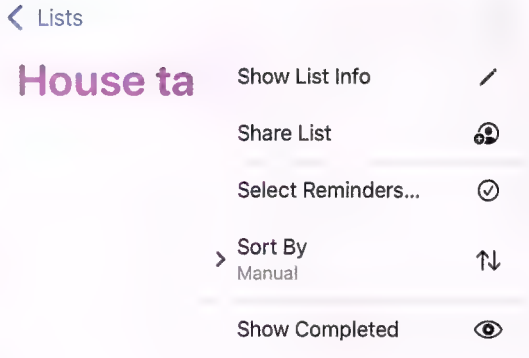


GENIUS TIP!
You can use the Reminders app to manage reminders in Microsoft Exchange, Yahoo or AOL, as well as iCloud Reminders.



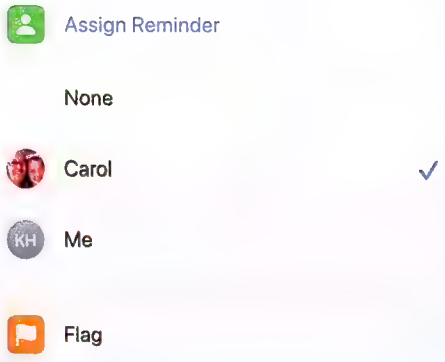
01 Create a new list

Before you can assign tasks, you need to create a shared list from which to assign them. In Reminders, tap Add List. Choose iCloud. Give the list a name, and, if you like, choose a colour for it and icon to represent it.



02 Share the list

Tap the list in the main Reminders screen. Tap the '...' at the top right. Choose Share List. Select a method by which to share the list. Add the people you want to share with as recipients, and a message. Tap Send.

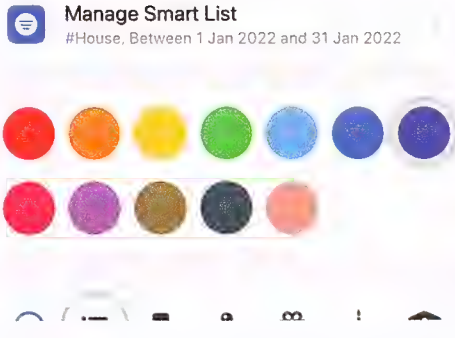


03 Assign a task

Once you're sharing a list, tap it, then tap New Reminder. Give the reminder a name. Add details such as a date, flag or location. Tap the head and shoulders and choose someone to assign the reminder to. Tap Done.

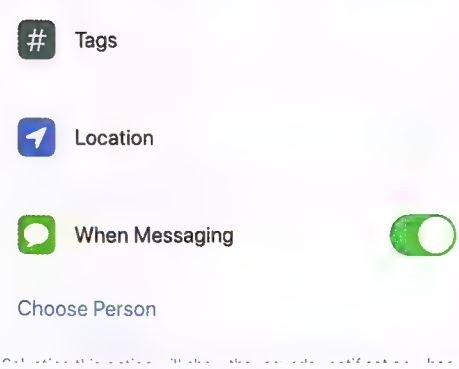
05 Create a Smart list

In Reminders' main screen, tap Add List and iCloud then give the list a name, colour and icon. Tap 'Make into Smart List'. Tap a filter to use it to automatically add tasks to the list. Choose a parameter. Tap Done.



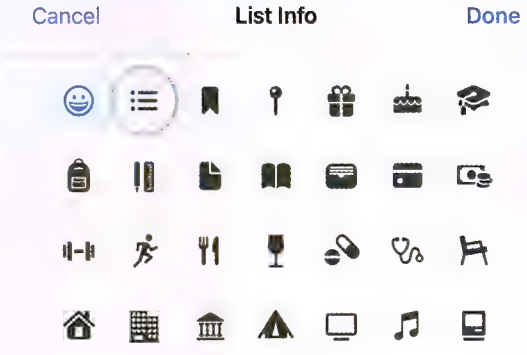
07 Add filters

When you convert a list, Reminders kicks you back to the main screen. Tap the list again, then the '...', and choose Manage Smart List. You can now add filters and parameters in the same way as in Step 5.



04 Another way to share

Instead of assigning a task, you can tell Reminders to remind you of a task when you message someone. Tap the task, then the 'i' next to it. Turn When Messaging on. Tap Choose Person. Tap a name. Tap Done.

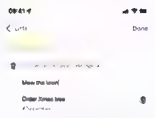


06 Convert to a Smart List

To convert an existing list to a Smart List, tap it then tap the '...' icon. Choose Show List Info. Swipe up and tap Convert to Smart List. You'll see a message saying a tag has been appended to tasks in the list.

08 Add tags

Tap any reminder in a list. In the options above the keyboard, choose the '#' symbol. Type the tag you want to add, then tap 'return'. Alternatively, tap 'i' next to a reminder and tap Tags on the next screen to choose one. ■



JARGON BUSTER

For our purposes, a **task** is the same thing as a reminder. We have used them interchangeably to avoid confusion with the name of the app.

GENIUS TIP!

Reminders are sorted by creation date, but you can change that by tapping the three dots, Sort by, and choosing another parameter.

Network-share files quickly and easily

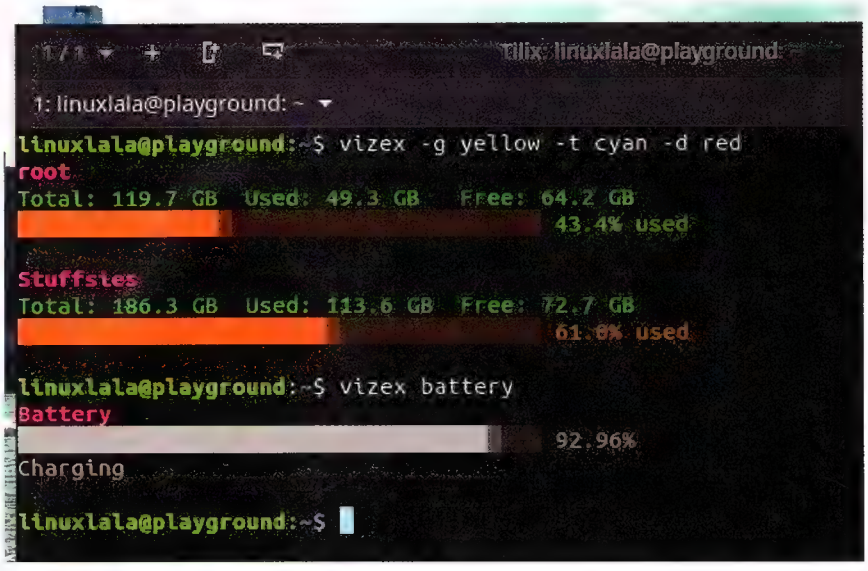
Nick Peers reveals how to share files over your local network without getting bogged down in networking protocols.

With ever-expanding disk capacities and fast dropping prices, you would think that checking disk space usage was an activity of a bygone era. While this might be true for casual home users who run a tight ship, if you're running an install-and-forget rolling-release distribution such as Arch, Gentoo or the like, you must keep an eye on disk space usage lest you find yourself out of storage room.

Linux distributions boast a number of graphical and text utilities that help you keep an eye on disk space. For regular users of the command line, *df* and *du* are among the most popular tools, but they produce a vast amount of mostly incomprehensible data. If you want your disk space usage presented in a stylist bar chart then Vizex is just the right tool for you.

It's far easier to assimilate vast amounts of information when presented in graph form. But knowing the right graph to use is just as important. Thankfully, Vizex uses bar graphs to full effect to present limited, but pertinent disk usage information. Unlike the `df` and `du` commands that need the `-h` command switch to be human readable, the data presented by *Vizex* is easier to make sense of.

Released under the MIT license, the Vizex project (**https://github.com/bexxmodd/vizex**) comprises three distinct command-line utilities. The original vizex utility presents the used and available disk space for all mounted partitions on the system. vizexdf can similarly be used to view information about the files and directories. With the latest v2.0.5 release, the project now also offers vizextree, which can be used to view the tree structure of the specified directory.



The different colour schemes are only for the vizex command, and can't be used when viewing either CPU or battery status.

Getting started

Vizex isn't available in the software repositories of popular desktop distributions but the Python project is fairly easy to install with Pip, which is a package manager for Python projects.

Arch users can install Pip with the `sudo pacman -S python-pip` command. If you're running Ubuntu or Fedora, or a derivative distribution, then you can similarly run the `sudo apt install python3-pip` or the `sudo dnf install python3-pip` command, respectively, to install Pip for Python 3.

With Pip installed, you can now install Vizex with the `pip install vizex` command. You'll then be able to upgrade Vizex to newer releases with the `pip install --upgrade vizex` command.

The Vizex project has a fairly long list of dependencies, mentioned in the **requirements.txt** file on the project's GitHub page (**https://github.com/bexxmodd/vizex**), and if you're prepared to resolve these yourself then you can even install Vizex using the **setup.py** installation script with the `python setup.py install --user` command.

Graphs are good

You can now run the `vizex` command to

GRAPH DISK I/O WITH DISKGRAPH

The Diskgraph utility (**https://github.com/stolk/diskgraph**) can be used to chart the IO data in real time. Written in C, the project has no dependencies to speak of, and if you already have gcc installed on your distribution you can install Diskgraph without any issues.

Download the repository with the git clone **https://github.com/stolk/diskgraph.git command**. Next, change into the downloaded diskgraph repository. You'll find a number of files, including Makefile. So, run the make command. That's it! You'll now notice a new executable diskgraph script.

The diskgraph utility requires a device to monitor, so run the ./diskgraph sda command to monitor the sda hard disk. You don't have to specify disks using the complete path such as /dev/sda although that is also supported.

The Diskgraph utility works by studying how many sectors are read or written to since the last interval. By default, the data is refreshed at every 500ms interval.

The red colour denotes write operations being performed. Green colour similarly signifies read operations. The orange colour shows in-flight operations, which are defined as I/O operations that have been issued but not yet completed. You must hit 'q' to exit Diskgraph.

As of now, it's not possible to change the default interval or the colours used to graph disk IO and there's no official man page to explain its functionality.

display the total disk space, the amount used and available.

```
$ vizex
root
Total: 119.7 GB          Used: 49.3 GB
Free: 64.2 GB
43.4% used

Stuffsies
Total: 186.3 GB          Used: 113.6 GB
Free: 72.7 GB
61.0% used
```

As you can see from the generated bar graph, the total size of the Stuffsies partition is 183.6GB out of which 113.6 GB or 61 per cent is used and 72.7GB is available. Unlike the `df` command which presents information for all mounted physical and virtual devices, Vizex ignored virtual devices by default. Use the `vizex –every` command option to view the graphs for physical and virtual devices.

If you also want additional information such as mount point and filesystem type for the different partitions, you must run the `vizex --details` command. You can also use the `--exclude` or `-X command` option to exclude partitions:

```
$ vizex --details -X root
Stuffsies
Total: 186.3 GB          Used: 113.6 GB
Free: 72.7 GB
61.0% used
fstype=fuseblk           mountpoint=/media/
linuxlala/Stuffsies
```

The partition name as well as all the text is colour-coded. Vizex enables you to define custom colours for the text and partition names:

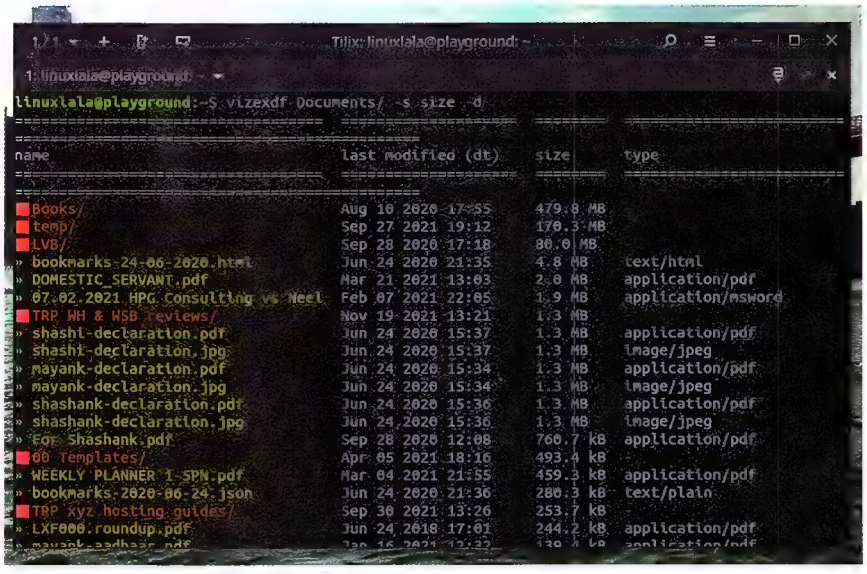
Command	Function
vizex -d [colour]	Define the colour for the partition name.
vizex -t [colour]	Define the colour of the text such as Total, Used, Free, etc.,
vizex -g [colour]	Define the colour of the bar graph.

Simply run the `vizex --help` command for a list of supported colours.

You can also use the Vizex utility to view battery and CPU information. The `vizex battery` command displays the battery information and lets you know if the battery is charging.

The `vizex cpu` command similarly presents real-time usage for each CPU. You must press Ctrl-c to exit:

```
CPU #1
Current: 1650.2hz || Min: 500.0hz || Max:
2000.0hz
76.68% used
CPU #2
Current: 1582.0hz || Min: 500.0hz || Max:
2000.0hz
72.13% used
CPU #3
Current: 1470.0hz || Min: 500.0hz || Max:
2000.0hz
64.67% used
CPU #4
Current: 1665.4hz || Min: 500.0hz || Max:
2000.0hz
77.7% used
```


Tilix: linuxlala@playground: ~
1: linuxlala@playground: ~
linuxlala@playground:~$ vizexdf Documents/ -s size -d
name
last modified (dt)
size
type
Books/ Aug 10 2020 17:55 479.8 MB
temp/ Sep 27 2021 19:12 170.3 MB
LVB/ Sep 28 2020 17:18 80.0 MB
bookmarks-24-06-2020.html Jun 24 2020 21:35 4.8 MB text/html
DOMESTIC_SERVANT.pdf Mar 21 2021 13:03 2.0 MB application/pdf
07.02.2021_HPC_Consulting_vs_Neel Feb 07 2021 22:05 1.9 MB application/msword
TRP_WH_&_WSB_reviews/ Nov 19 2021 13:21 1.3 MB
shashi-declaration.pdf Jun 24 2020 15:37 1.3 MB application/pdf
shashi-declaration.jpg Jun 24 2020 15:37 1.3 MB image/jpeg
mayank-declaration.pdf Jun 24 2020 15:34 1.3 MB application/pdf
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shashank-declaration.pdf Jun 24 2020 15:36 1.3 MB application/pdf
shashank-declaration.jpg Jun 24 2020 15:36 1.3 MB image/jpeg
For_Shashank.pdf Sep 28 2020 12:08 760.7 kB application/pdf
00_Templates/ Apr 05 2021 18:16 493.4 kB
WEEKLY_PLANNER_1-SPN.pdf Mar 04 2021 21:55 459.3 kB application/pdf
bookmarks-2020-06-24.json Jun 24 2020 21:36 280.3 kB text/plain
TRP_xyz_hosting_guides/ Sep 30 2021 13:26 253.7 kB
LXF000.roundup.pdf Jun 24 2018 17:01 244.2 kB application/pdf

The different Vizex utilities don't ship with a man page, so you must run the vizex --help or the vizexdf --help command.

Linux distributions boast a number of graphical and text utilities that help you keep an eye on disk space. For regular users of the command line, df and du are among the most popular tools, but they produce a vast amount of mostly incomprehensible data.

Using vizexdf

The vizexdf utility presents tabular information for the specified directory and includes information such as name, last modified, size and type. If no directory is provides then Vizexdf produces output for the current working directory.

Vizexdf ignores hidden files by default, but you can include them in the output by using the `-a` command option. It's also possible to sort the output based on name, file type, size or modification date using the `-s` command option. By default, Vizexdf presents information in ascending order but you can use the `-d` command option to have the data presented in descending order. Naturally, the `-d` command option only works with the `-s` command option. For instance, the command `vizexdf -s name -d ~/Documents` will sort all the files and directories in the **~/Documents** directory in descending order based on name. The `vizexdf -s size -d ~/Downloads` command can similarly be used to show the contents of the **~/Downloads** directory sorted in descending order based on size.

Analysing tree structure

The `tree` command can be used to view contents of a directory in a tree-like format. The vizextree utility provides similar functionality, and makes it possible for you to restrict the output to a defined level, which limits the number of child directories or files that are displayed.

For instance, the `vizextree -l 1 ~/Documents` command limits the output to seven directories and 74 files, whereas the `vizextree -l 2 ~/Documents` command covers 11 directories and 144 files

The vizextree utility only provides this limited functionality. If you want more advanced features such as limiting the output based on patterns, or listing directories only, then you would be better off with the `tree` command. ■

RASPBERRY PI

Booting multiple operating systems

Christian Cawley examines the various ways you can boot your Raspberry Pi, from installing an OS to multibooting.

Booting an operating system on the Raspberry Pi is straightforward, but the tools used for the process have changed over the years. Since the release of the Raspberry Pi 4 and the Pi's slightly different architecture, new utilities have been developed, both for single installations and for multibooting. Meanwhile, the price of SD cards has plummeted.

While the basic tools – Raspberry Pi Imager, Etcher and so on – are suitable for single booting, BerryBoot is particularly useful for multibooting, as is NOOBS. There is also a web-based solution that automates single and multiboot installations via your browser, called PINN. Everything explained here assumes you're using a Raspberry Pi with a keyboard, mouse and monitor attached, with an accessible network connection.

The Raspberry Pi has a decent selection of operating systems available, from the default Raspberry Pi OS and various lightweight alternatives to things such as RetroPie and Recalbox for retro gaming, OSMC and LibreElec for running a Kodi-based media centre, and many more besides.

Installing a single operating system requires you to first download the image file for the OS. This is typically in .IMG format, usually around 5GB in size. Many can be found on the Raspberry Pi website (**www.raspberrypi.com**) when you click the Software. Others can be found by searching further afield. Here we'll look at the various options you have for installing a new operating system on a Raspberry Pi.

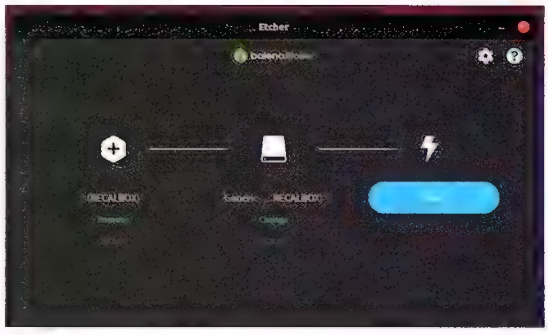
Raspberry Pi Imager

Taking the place of NOOBS as the de facto installer, and pushing Etcher down the pecking order, Raspberry Pi Imager is a multiplatform utility for writing a single operating system to an SD card. Start by grabbing it from the Raspberry Pi website (**www.raspberrypi.com/software/**) and installing on your computer. You can also install the Snap package from the terminal with:

```
snap install rpi-imager
```

With the software installed, insert the SD card into your computer's card reader then load Raspberry Pi Imager. Start by selecting the media in Storage – this ensures you get a full selection of the available operating systems available in Raspberry Pi Imager.

Next, click Choose OS to select the operating system you want to install. You'll find standard operating systems, gaming OSes, media centres, Russian language options, along with utilities to reset an Raspberry Pi OS and even wipe the SD card. To install an OS already downloaded to your computer, choose Use Custom.



Take an Etcher-sketch of your preferred Raspberry Pi operating system with this efficient utility.

Raspberry Pi Imager also has a secret screen, available by pressing Ctrl-Shift-X. This enables some preset configurations to be made, such as SSH, Wi-Fi configuration, hostname and more. Click Save to bake these into the installation (the tool has essentially replaced the popular Raspberry Pi Bakery utility) then select Write to start copying the disk image and settings to your microSD card.

Once complete, and after safely ejecting the SD card from your computer, the Raspberry Pi can be booted with the new OS.

Install with Etcher

An alternative to Raspberry Pi OS, Etcher is similarly available on Linux, macOS and Windows, enabling complete flexibility when it comes to installation of your chosen Raspberry Pi

BOOTING MEDIA OPTIONS FOR RASPBERRY PI

Using a microSD card to boot the Raspberry Pi isn't the only option you have. The Raspberry Pi 4 and 400 both support booting from USB rather than a microSD card. This opens up a range of options. USB flash sticks, USB hard disk drives, solid-state drives with USB, even NVMe devices with a USB adapter can be hooked up to the Pi 4 to boot up.

Most of these devices are likely faster than a standard microSD card, and certainly more resilient. Consequently, the option is now available to prioritise disk speed and performance by choosing to move away from the traditional microSD booting method.

Enabling booting for the Raspberry Pi 4 and 400 is straightforward, but can only be done easily using Raspberry Pi Imager. When selecting the operating system, scroll down the menu to the Misc utility images sub-menu. Here, select Bootloader, then USB Boot. With this set, the Pi will boot from an attached USB device, or if this is unavailable, will try to boot from SD.

Next, in the Storage menu, select the SD card, then Write the image. Once complete, and with the Pi booted from the SD card, attach the USB device to boot from.

In the Pi's desktop menu, select Accessories then SD Card Copier. Use this to copy the image from the microSD card to the USB storage. Once complete, shutdown the Raspberry Pi, remove the microSD card, and power up. The computer will now boot from the attached USB drive.

operating system.

The easiest option is to grab the AppImage file from the Balena website (**www.balena.io/etcher/**), unzip it, then double-click the extracted file (balena Etcher-x.x.x-x64.AppImage, "x.x.x" is the version). The software will run instantly, giving you three options.

The first, Flash from file, enables you to use a downloaded image. Flash from URL is for fast internet connections, typically, allowing you to choose an OS stored at a specific location (a bleeding-edge release). There is also a Clone drive option suitable for backing up existing flash media. Note that Etcher can be used with SD cards and USB flash devices.

To use Etcher to write a downloaded Raspberry Pi operating system to your chosen flash media, select Flash from file, then Select target. Here, find the drive to write to, then Flash to start the process. After completion and safe removal of the disk media, the new OS should boot in the Raspberry Pi.

Using the terminal

You can also write a Raspberry Pi operating system disk image to an SD card using the terminal.

First, download the disk image you want to use. Next, insert the SD card into your computer's card reader. In the terminal, search for the SD card in the /dev/ directory with `sudo ls -ltr /dev/*` .

The card should be listed as `mmcblk0`. Ignore references to partitions on the card (`mmcblk0p1`, `mmcblk0p2`, and so on.) because you need the entire SD card for this. Check the location of the downloaded IMG file before proceeding, then enter:

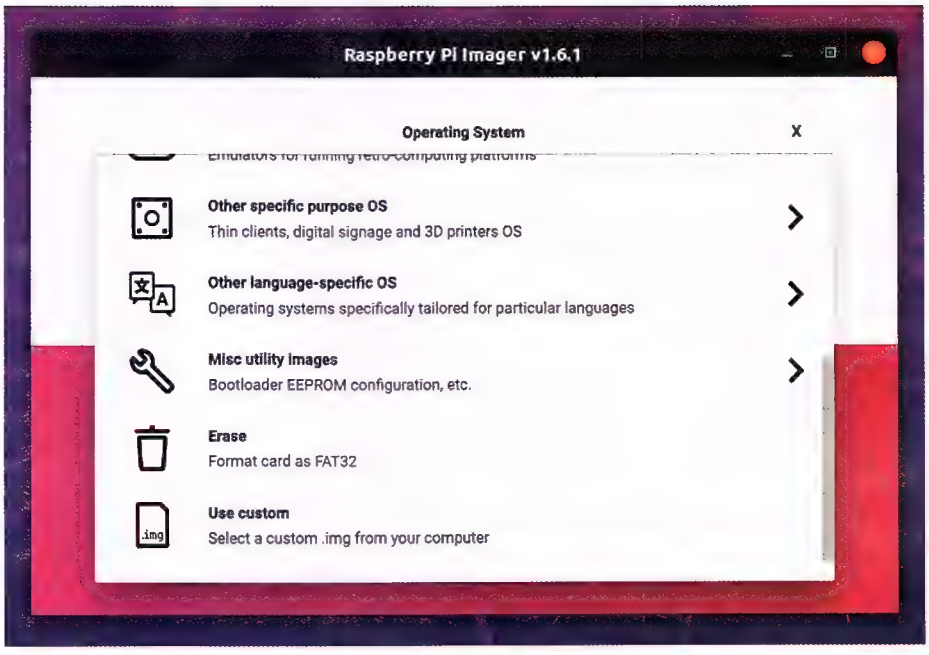
```
sudo dd bs=1M if=/path/to/raspberrypi/image of=/dev/sdcardname status=progress conv=fsync
```

Substitute `if=` with the path to the IMG file, while `of=` should match the name of the SD card.

Tap Enter to run the command. When complete, you'll be ready to boot the SD card in your Raspberry Pi.

Multiple operating systems

If you only have one Raspberry Pi and want to maximise the possibilities, installing two or more operating systems is a smart option. For example, you could run a Kodi media centre alongside RetroPie for retro gaming. You might even throw a full desktop distro in there too, for productivity or programming.


Raspberry Pi Imager v1.6.1
Operating System
Other specific purpose OS
Thin clients, digital signage and 3D printers OS
Other language-specific OS
Operating systems specifically tailored for particular languages
Misc utility images
Bootloader EEPROM configuration, etc.
Erase
Format card as FAT32
Use custom
Select a custom .img from your computer

The secret screen in Raspberry Pi Imager enables you to set some useful configurations for the current and future sessions. Investigste the drop-down menu at the top.

Three options are available for multibooting a Raspberry Pi. BerryBoot, NOOBS and PINN are all intended to install multiple IMG files on a microSD card, along with the requisite boot menu and any other configurations. Not the most well-known solution to Raspberry Pi multiboot but certainly the first, BerryBoot was first released back in 2012. The latest release supports Rasberry Pi 3, 4, and 400 models.

Using this software to dual-boot or multiboot a Raspberry Pi is straightforward. Start by downloading the BerryBoot ZIP file (**berryterminal.com/doku.php/berryboot**) to your PC and extract the contents. Next, copy the files to the root of your FAT-formatted microSD card.

After safely ejecting the SD card, insert it into your Raspberry Pi and boot up. The first thing you see is the BerryBoot configuration screen, where you can resolve any overscan issues and establish a network connection. Take the time to set the Locale settings correctly, as not doing so will lead to problems later.

Click OK, then select the device where the operating system(s) will be installed. BerryBoot's strength is

QUICK TIP
If you're writing a Raspberry Pi disk image on a non-Linux OS, Raspberry Pi Imager and Etcher offer a largely similar experience. Use Imager for pre-configuring network settings, or just use Etcher.

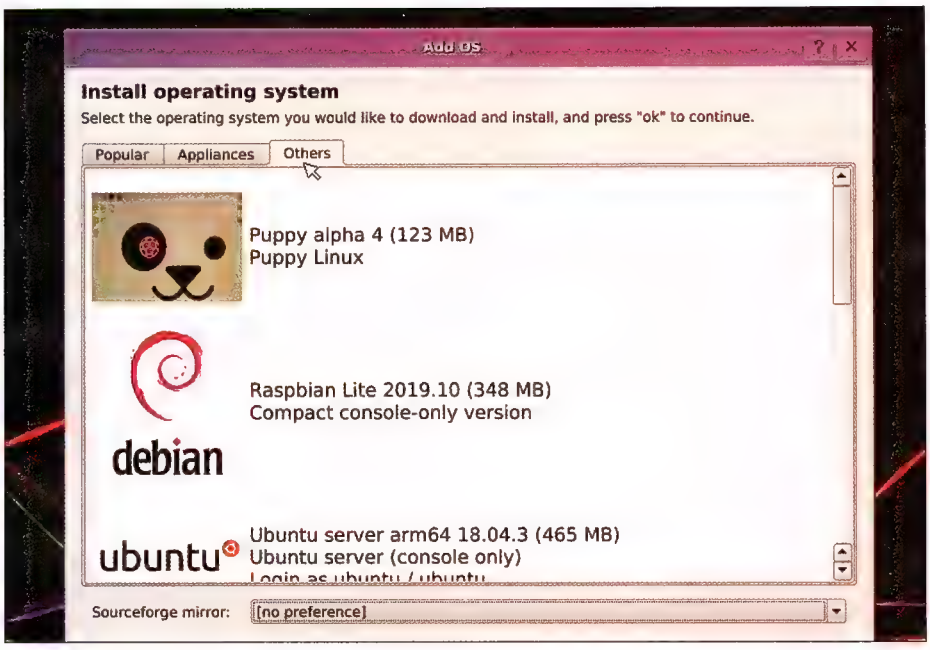
THE PIDRIVE LEGACY

Released for the Raspberry Pi 3, WD Labs' PiDrive system married the Pi with a hard disk drive and dedicated cases. There was even a module for attaching a Pi Zero to an HDD, creating an instant server.

These devices are long since discontinued, although they appear occasionally on eBay. Their lasting legacy is that they demonstrated how the Pi can be paired with larger, faster storage. As Raspberry Pi 3 was the first model to have the ability to boot from USB (thanks to a complicated and occasionally Pi-breaking process), it made sense that someone should release it alongside a dedicated disk drive.

But that wasn't all it shipped with. While the low-power USB HDD was a key addition, the PiDrive system also required some software. Dedicated versions of NOOBS and BerryBoot were released with PiDrive, and while the BerryBoot build is long gone, there is a community-maintained version of NOOBS for PiDrive.

Known as the PiDrive Community Foundation Edition, this is maintained on GitHub (**https://bit.ly/LXF285-pidrivenoobs**) and has been updated to support Raspberry Pi 4. This makes it suitable for those planning to upgrade an existing PiDrive system from Pi 3 to Pi 4.



supporting multiple OSes, each in their own partition, accessed via a boot menu. Any locally or network attached drives can be detected and selected here. You can also format the device if required. This includes the SD card, which will format the space beyond the boot/ directory.

After any formatting is completed, the Add OS menu is displayed. Popular operating systems, Appliances (currently just NOC-PS Lite, a PXE network installation tool), and various Others are listed, covering everything from retro gaming and media servers to Puppy Linux. Simply check the box for the preferred OSes, click OK, and when prompted set one as the default. Click Exit to commence downloading of the operating systems.

BerryBoot features some advanced tools, too. Once the OSes are installed on the SD card, you can Backup, Edit config, Clone, or even Delete an operating system. Problems can be resolved using the Repair file system button, or resolved in the Console.

The configuration editor is probably the most useful of all these, providing direct access to config.txt. Here, you can manage gpu_mem, edit the bootmenutimeout property, and make various other tweaks to improve performance of the multiboot system.

Not for NOOBS

No longer offered as a linked download from the Raspberry Pi website (although it remains hosted there), NOOBS (New Out Of Box Software) remains accessible via GitHub. Initial setup is similar to BerryBoot. Download the latest version from GitHub (**github.com/raspberrypi/noobs**) and unzip the contents to FAT-formatted SD card.

NOOBS comes in two versions. The standard NOOBS is a bigger download with several operating systems bundled in, for offline installation. Meanwhile, NOOBS-Lite is smaller, but downloads the chosen operating systems if your Pi is networked. NOOBS-Lite is useless without a network, so ensure the computer is connected if using this option.

After safely ejecting the media and booting the Raspberry Pi with it, NOOBS will start, providing several OSes to choose from. These include Arch Linux, OpenELEC Kodi, RISC OS, and of course Raspberry Pi OS, among others. To install the OSes, check the box, keeping an eye on the disk space (displayed at the bottom of the screen). If using NOOBS-Lite and you intend to download over Wi-Fi, connect the Pi to your network in the Wi-Fi networks screen. Meanwhile, you can tweak the configuration in the Edit config screen. This provides editable access to config.txt and cmdline.txt. When ready, click Install.

After completion, the Raspberry Pi will reboot into the NOOBS boot selector. This will display for 10 seconds, with the first OS selected. Subsequent boots will display the last-used OS. If you've installed a single OS, no boot screen will be displayed.

Use BerryBoot to ensure the best speed for your installation by choosing a specific source using the dropdown at the bottom of the screen.

QUICK TIP

Safely ejecting any flash media from a powered-up computer is vital for data integrity. Getting this wrong, and ejecting (or powering off) while data is still being written or read from the device, can result in corruption.

PINN it

Perhaps the most flexible of all multibooting solutions, PINN is largely browser-based. This enables you to configure your Raspberry Pi from almost any device and download the resulting multibooting setup, ready to copy to your microSD and boot. Note, however, that this solution also requires a network connection. Full instructions can be found in the walkthrough (opposite).

BEST MULTIBOOT CONFIGURATIONS

Interested in multibooting your Raspberry Pi? Choosing the right combination of operating systems will save considerable messing around later on. But what's the best mix? While it depends on which multiboot system you're using, here are some suggestions that can be put together using PINN, the web-based multiboot configuration tool.

For a system that balances gaming and media, you can install Recalbox and Lineage, delivering the full entertainment centre experience. A more lightweight alternative is RetroPie and OSMC, which have smaller disk space requirements.

Have desktop requirements? Two paths here are to add a full Raspberry Pi OS, Ubuntu 20.10, Gentoo, or Manjaro to any of the above. You might even install all four.

Small hard disk drive, or just need an OS that does the basics? PINN has Arch, DietPi, Gentoo64lite, and Raspberry Pi OS Lite. Of these, Arch is the most lightweight option. Any of these can be teamed up in a multimedia multiboot configuration, too, as the accessible desktop alternative.

The best configuration is down to your own requirements, and what you expect from the Raspberry Pi. See the walkthrough (opposite) on using PINN for more information on using the tool.

Danger Eben Upton!

Installing and booting two or more operating systems might seem to deliver a new level of convenience to your Pi, but it doesn't come without risks. These are worth particular attention if you're installing to an SD card.

The main risk is the impact on the media itself. If you've ever experienced a Raspberry Pi OS or Raspbian corruption, then you'll know how frustrating this can be. Those occasions probably only occurred using a single OS, with the Pi writing and reading data to and from the SD card in a single partition.

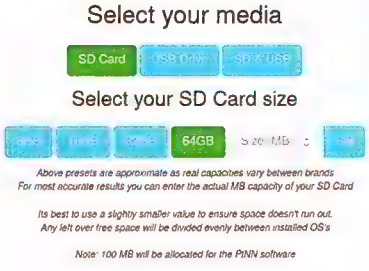
Multiply that by two, three or more, and there's a greater chance of the media suffering a corruption and the partition failing. Coding files, Kodi plugins, retro game ROMs, whatever – they're all lost.

As such, while NOOBS and BerryBoot are suitable for use with SD cards, if you're taking the multibooting approach then using a HDD, SSD, or NVMe device makes more sense. With more robust, faster hardware, the chance of failure is reduced.

Take a bigger bite of the Pi

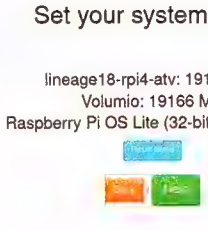
Installing an OS has become increasingly simple with the arrival of the Raspberry Pi 4. If you have a suitable USB HDD or plan to buy a case that accommodates a disk drive (such as the Argon ONE series or DeskPi Pro) then multibooting is far more reliable. This opens considerable possibilities, not least a single Pi system able to reliably switch between different purposes with a single reboot. Whether switching between different Linux distros or specialist OSes for gaming and media, multibooting brings considerable new flexibility to an already versatile computer system. ■

HOW TO Create a multiboot image with PINN


Select your media
SD Card
Select your SD Card size
64GB
Above presets are approximate as real capacities vary between brands
For most accurate results you can enter the actual MB capacity of your SD Card
Its best to use a slightly smaller value to ensure space doesn't run out.
Any left over free space will be divided evenly between installed OS's
Note: 100 MB will be allocated for the PINN software

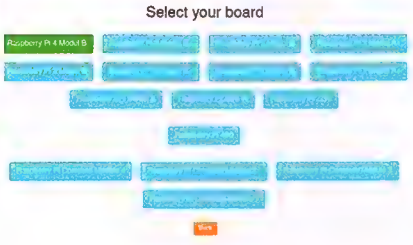
01 Select an SD card size

Multibooting your Raspberry Pi doesn't have to rely on BerryBoot or any other downloadable tool. With PINN, you can manage it all in your browser. You'll find the PINN tool at **https://pinn.mjh.nz**, where you're immediately prompted to select your storage device and capacity. You can choose an SD card, USB storage or a mix of both; note that 100MB is reserved for the PINN software.



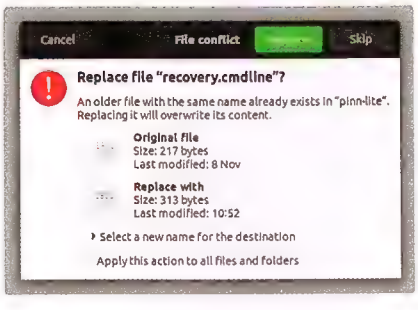
04 Set your system sizes

Your chosen operating systems each require enough space to run effectively. You can help here using the slider to determine how much disk capacity each operating system partition will have. With two operating systems, there's a single slider; three OSes means two sliders, and so on. Adjust the slider as necessary, ensuring that each OS you have chosen has enough additional storage space.



02 Choose your Pi model

With the correct media and capacity selected, choose the Raspberry Pi board you'll be using. Every option is available here, covering A boards, B boards, Zeros and Compute Modules, so choose the correct model with care. There are differences between standard and plus (+) models, so be sure to make the right choice here. If you misclick at any point, simply click Back to retry.

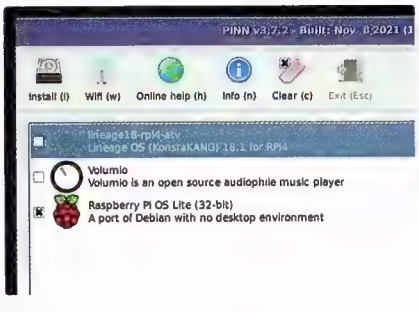

Cancel
File conflict
Skip
Replace file "recovery.cmdline"?
An older file with the same name already exists in "pinn-lite".
Replacing it will overwrite its content.
Original file
Size: 217 bytes
Last modified: 8 Nov
Replace with
Size: 313 bytes
Last modified: 10:52
Select a new name for the destination
Apply this action to all files and folders

05 Download your disk image

After clicking Next, download PINN-lite using the button, along with a file called recovery.cmdline. This shouldn't take too long. With your media attached to the computer, unzip PINN and then copy recovery.cmdline into the pinn-lite directory, overwriting the existing file. This file includes instructions for downloading and installing your chosen OSes and partition size.

03 Choose operating systems

Next, select from one or more operating systems for the Raspberry Pi, arranged by type. The choice covers minimal systems, gaming, utilities, testing, general operating systems and media centres. Click an OS to select it for your multiboot system; click again to deselect. Watch the Required figure at the top of the screen, and ensure that it stays below the Available capacity. Click Next to continue.



06 Create your multiboot Pi

Finish by copying the contents of pinn-lite to your selected Raspberry Pi media, then safely ejecting. Power up to load the PINN environment, then connect the Pi to the network, either using Ethernet or press W to configure Wi-Fi. Select your intended operating systems, click Install, and wait for installation. When the device reboots you'll see a boot selection screen, ready for your choice.

CPUs and microcontrollers: what's the difference?

They're the brains in everything from your car and TV to your fridge and washing machine, but what are microcontrollers and how do they differ from your PC's CPU? Darren Yates explains.

Power up your PC or laptop and within seconds, you can be running all sorts of apps – everything from online dating to printed circuit board layout design. The CPUs inside your favourite computing devices are 'general purpose' in that they can turn their hand to almost any application. They're the SUVs of the computing world. By comparison, microcontrollers units (MCUs) are single-minded. They appear in applications where they usually have just one job to do – and do it incredibly well. If CPUs are the SUVs, then microcontroller units are the nimble trail bikes that go almost anywhere. This month, we look at how MCUs work, what they can do and why they're heaps of fun.

One-stop shop

AMD's Ryzen Threadripper 3990X is a remarkable chip – a huge 64 cores and more cache RAM than my first two PC hard drives had storage. But as with Intel's Core range as well, even the best PC CPUs can't do anything without external RAM and storage for code. They also need a motherboard's worth of extra input/output (I/O) tech to interact with the real world and that's okay, because their scope is incredibly broad.

Microcontroller units, by contrast, are designed to be lightweight, self-contained processing systems that don't need anything else (or an absolute minimum of extras) to perform the one specific task they're coded for. Just like dirt-bikes, this gives them a real 'go anywhere' advantage in single or 'embedded' applications where they can be applied without the semi-trailer bloat of a full-blown operating system.

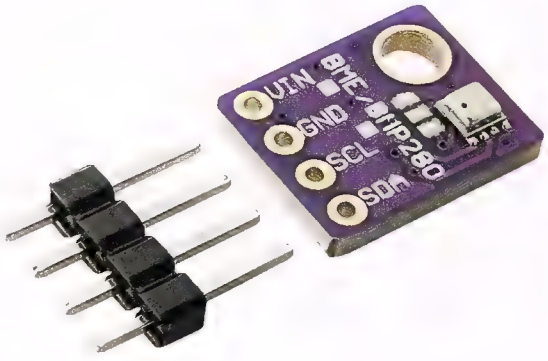
Core, Clock, Bits, RAM, Flash

Microcontrollers are typically single-core processing engines, although dual-core options like the Espressif Systems ESP32 are now available. Unlike your PC, though, the clock speed of a microcontroller is generally fixed – it's adjustable to a limited extent, but while it's running, it's locked to a set rate (in some cases, as much as 1000-times slower than your PC).

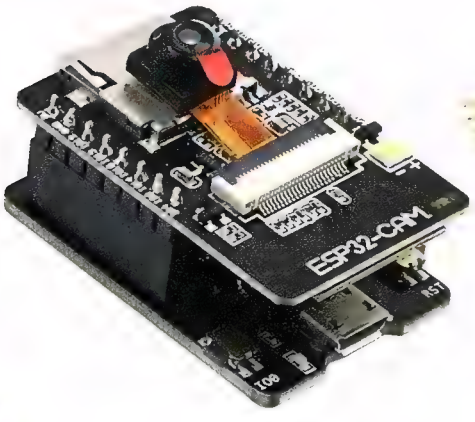
MCUs also come in three broad classes – 8-bit, 16-bit and 32-bit. The 8-bit microcontrollers are the oldest and most well-known on original 'Arduino' maker boards. These are a bit like old Commodore 64 and TRS80 home computers, but in a credit card-size circuit board. The 16-bit MCUs are less-common and mostly made by Microchip under its 'PIC' brand. The most powerful are new 32-bit units with roughly similar processing capacity to a 1990s Intel Pentium CPU.

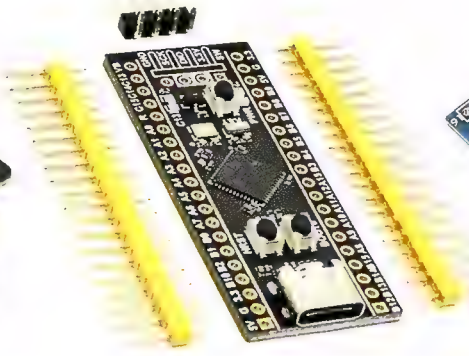
Your Android phone features a CPU powered by multiple ARM Cortex A-series CPU cores created by designer ARM. It also designs MCUs under its 'Cortex M' brand that are equally as popular. But as MCUs are easier to make, there are many other brands, including Microchip and its former rival Atmel, STMicroelectronics, Espressif Systems, even Intel and AMD.

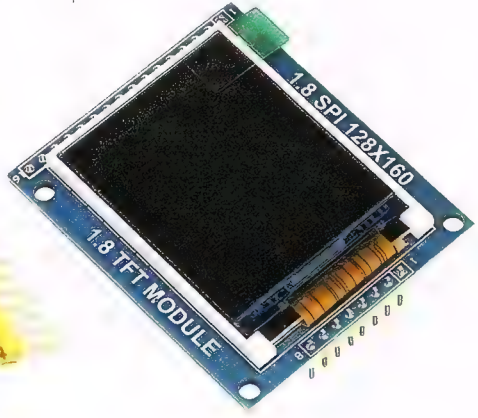
MCUs come with their own RAM and flash storage, but it's often difficult to get your head around how little of it they have – or need. The ATMEGA328 MCU that powers the Arduino Uno, arguably the world's most popular maker board, has just 2KB (2,048 bytes) of RAM and 32KB of flash storage. More modern 32-bit MCUs will have up to 512KB of RAM and even 4MB of flash storage, but since they run code directly without an OS ('bare-metal coding'), they don't waste it.



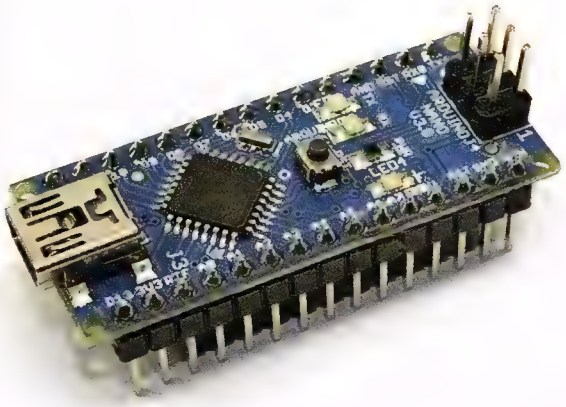
The Bosch BME280 sensor provides temp, humidity and pressure readings for $5.

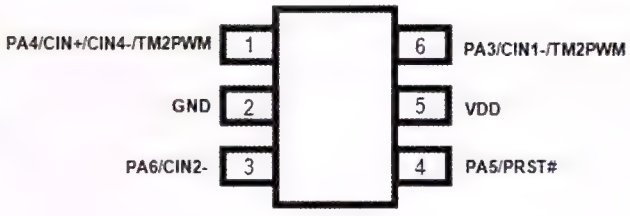




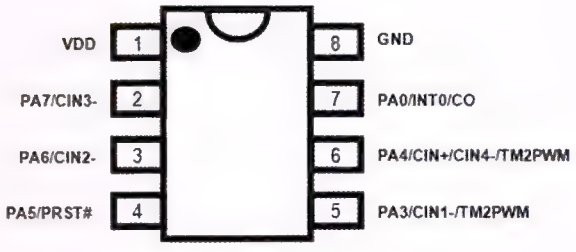


Below Left: The ESP32-CAM has an ESP32 MCU with a 2MP camera for $15 on Ebay.
Below middle: The new $10 STM32F411 'black pill' maker board has a 100MHz Cortex-M4 MCU chip.
Below right: The SPI bus lets you connect small LCD screens like this 1.8-inch unit, selling for $10.





PMS150C-U06 (SOT23-6 60mil)



PMS150C-S08 (SOP8-150mil)
PMS150C-D08 (DIP8-300mil)

Above: The original Arduino Nano maker board with its 8-bit MCU is still available.
Right: The Padauk PMS150C 8-bit MCU sells for just five-cents each in 10-off quantities.

Power consumption

Another thing to consider is that higher clock speeds and more RAM also require more electrical power, so for most product designers, it's usually a case of building in just enough resources to do the job required. For example, a Core i5 CPU will run at a voltage of just over one-volt (1V) but may require up to 30 amps (30A) or more of current. By contrast, the STM32F103 board you can buy on Ebay for under $10 with its Cortex-M1 MCU runs at 3.3V but consumes less than 30-milliamps (0.03A). This low power-consumption is why MCUs are great for outdoor sensors running all-day every day and powered by solar-charged battery systems. It's also why the BBC Micro:bit student board can run for the better part of a week on a pair of 'AAA' batteries.

Cost

When you scale down the scope and performance, you can also scale down the cost. A shiny new Core i5-12600K CPU might cost you $460 on the street, but you can buy an 8-bit MCU for as little as five-cents U.S. (if you buy ten). The Paduak Tech PMS150C 8-bit MCU has just 64 bytes of RAM and 2KB of one-time programmable flash storage, but for easy tasks like flashing LEDs, it'll do the job. More practical 'maker boards' that are ready to use sell for $10 on Ebay and feature the STM32F411 MCU, a 100MHz Cortex-M4 chip with 128KB of RAM and 512KB of flash. You can even buy 240MHz dual-core ESP32 maker boards that come with a tiny attached 2MP camera, plus Wi-Fi and Bluetooth (called the 'ESP32-CAM') for under $15, including shipping.

With I2S, you can connect up the $5 PCM5102A DAC with Blu-ray-grade audio specs.

The CPUs inside your favourite computing devices are 'general purpose' in that they can turn their hand to almost any application. They're the SUVs of the computing world.

Input/Output

However, from my perspective, MCUs rock because of their incredible I/O versatility, enabling them to connect to all sorts of real-world scenarios. These connection or interface standards can include I2C, a two-wire serial data interface or 'bus' used by many sensor modules, such as Bosch's BME280 temperature, humidity and barometric pressure sensor. Another is I2S, similar to I2C, but for audio – use this to connect Blu-ray-quality DACs (digital-to-analog converters) and make your own audio player. Yet another is Serial Peripheral Interface or SPI. With this, you can connect up small LCD screens and MicroSD card readers. Beyond that, there are Bluetooth modules and Wi-Fi interfaces that can connect your design to your phone or the Internet.

While these are all well-defined interface standards, MCUs also have basic input and output connections that allow you to hook up whatever you want (within reason), whether it's outputting to an LED, a transistor or a motor control system for making robots, or getting input from a light-dependent resistor (LDR) or pushbutton switch.

Hardware and software

However, the real difference between CPUs and MCUs is that with CPUs, your focus is almost solely on the software code – once it works, you're pretty much done. But with MCUs, you're not just dealing with software, you're also working with electronics and hardware. It's a bigger, but I think in some ways, more rewarding task because you have something tangible, something you can hold or point to at the end and say 'I made that' – and that's a pretty satisfying feeling. ■

Texas Instruments TI-99/4A (1981)

John Knight explores one of the classic 'coulda-been' computers.

This month we feature a cult computer that could have dominated the early 1980s but fell short of fame due to bad management decisions. Instead, machines such as Sinclair's ZX80 and ZX81 and the Commodore VIC-20 became the standard-bearers for a new era of home computing. Nevertheless, the TI-99/4A had a sizeable following, offering retro computing fans a combination of features not found elsewhere and some interesting arcade action.

The shape of the TI-99/4A's cartridge bay and its hot electronics, earned it the nickname "coffee cup warmer".

Specifications
CPU: TI TMS9900 @ 3 Mhz **RAM:** 16KB, 256 bytes Scratchpad RAM **Graphics:** TMS9918A chip – 16 colours @ 256 x 192 **Sound:** TMS9919 or SN94624 chip, 3x voices, 1x noise **OS:** TI BASIC **Storage:** Cartridge, cassette, 5.25-inch floppy **Released:** June 1981 **Worldwide sales:** 2.8 million

Development & release

Before the TI-99/4A came 1979's TI-99/4. When 8-bit microcomputers were just becoming mainstream, Texas Instruments (TI) had the ambition of releasing a 16-bit home computer, based on its own TMS9900 CPU.

As the first 16-bit home computer, this machine had the potential to dominate the home computing scene, with a 3MHz CPU, 16KB of RAM, 15 colours, 32 single-colour sprites, and 4-channel audio, powered by Texas Instruments' own chipsets.

However, the TI-99/4 had a botched launch. The TI-99/4 only received a chiclet keyboard. Wanting to keep tight control over software licensing, TI only gave developer information to a few software houses. To get around strict requirements from the FCC, TI simply bundled a modified colour television with their computer, greatly increasing its price.

The TI-99/4 launched for US$1,150 (around AUD$5,600 today), but it flopped, selling somewhere between 20,000 and 100,000 units. It was too expensive, the keyboard was nasty, and the company's strict software policies resulted in few applications.

Nevertheless, Texas Instruments didn't give up on its machine, returning in June 1981 with the TI-99/4A. The new "A" model still had the same CPU and RAM, but improved on its older sibling with a full-stroke keyboard, lower case characters, and a new TMS9918A video chip, later used in the Sega SG-3000 and MSX, which allowed bitmapped graphics.

Relaxed FCC regulations meant TI's new machine could be used with regular television sets, allowing a drastic price reduction. At just US$525, the TI-99/4A was now market competitive.

The adorable Texas Instruments' demonstration cartridge would make a great background display at a LAN party.

Performance & gaming

Don't expect Amiga-like performance from those 16 bits. TI's shoehorning of a 16-bit processor into a mostly 8-bit system didn't work. Workarounds were used to interact between the 8 and 16-bit components, and the 16-bit portion could only access 256 bytes of 'scratchpad' RAM and 8KB of ROM.

Nevertheless, the TI-99/4A still has tricks up its sleeve. The TI-99/4A is more graphically sophisticated than most machines of the early '80s, with smooth motion and proper sprite handling.

For example, *TI Invaders* (1981) is an excellent *Space Invaders* clone, with animations and independent colouring. 2014's remake of *Sabre Wulf* is superior to the ZX Spectrum release, with smoother movement.

However, the system's most impressive asset is its Speech Synthesiser add-on, which uses the same chips as Texas Instruments' Speak & Spell toys. Although other microcomputers had similar add-ons, the TI-99/4A's was employed much more extensively, featuring in arcade titles, educational packages, and even BASIC games.

Examples are *Alpiner* (1982), a mountaineering game, and *Parsec* (1982), a side-scrolling space shooter. For more general gaming recommendations, try *Hunt the Wumpus* (1980), *Tombstone City* (1981),

Space Bandits (1983), and *Tunnels of Doom* (1982).

Legacy

The TI-99/4A wasn't a financial success. TI was lured into a price war with Commodore, whose VIC-20 was cheaper to manufacture. Once TI price-matched Commodore, it was forced to sell the TI-99/4A at a loss, hoping to regain them through software licensing. This was the beginning of the end for the TI-99/4A.

While Commodore was accommodating to developers, TI refused to release technical specifications to third parties, implementing a lockout system against third-party cartridges.

By mid-1983, Texas Instruments announced a $100 million loss and retailers grew wary of the system. By Christmas 1983, the TI-99/4A was being sold from bargain bins for as little as $49. After selling 2.8 million units, the TI-99/4A was discontinued in March 1984, as the company moved towards IBM-compatible PCs.

Emulation

There are several emulators for the TI-99/4A, but our choice is Classic99. It's open-source, has a simple interface, comes with cartridges, and doesn't require BIOS files.

Unfortunately, Classic99 is only available for Windows but works well through Wine. Emulators for Linux do exist, but Classic99 via Wine will still provide the most painless experience.

The Classic99 website provides a ZIP file via a link on the front page. Download and extract the ZIP file, then open the classic99 folder, which has the classic99.exe executable file. Once launched, Classic99 will open at the master title screen.

Loading cartridges

Cartridges (called "command modules") are the easiest format to load. You can choose either from a selection in the Cartridge menu, or you can load cartridge files manually.

To load a cartridge manually, open the Cartridge menu and select User > Open. This will open a file browser, from which you can select your cartridge file.

Once selected, your emulator will reset to the master title screen, with the message "READY-PRESS ANY KEY TO BEGIN". Some cartridges will load straight away, while others give you the choice of 1, loading BASIC, or 2, loading the cartridge program.

Loading cassettes

Cassettes are harder to load than cartridges but easier than disks.

FINDING SOFTWARE?

Archive.org has a good software selection by the TOSEC team. If you need any more help or resources, **www.99er.net** is an excellent resource, along with **www.ti99iuc.it**, which has TI-99/4A games that can be played online.

Many games will require you to press either "Redo" or "Back". These are mapped to Alt-8 and Alt-9, respectively. See the Classic99 documentation for further key mappings.

Parsec is one of the TI-99/4A's best titles. Its extensive voice synthesis was ahead of its time for rival '80s micros.

Classic99 supports WAV files for cassette audio.

For the best chance of loading, first load the Extended BASIC cartridge by choosing Cartridge > Apps > Extended BASIC.

When the emulator resets, press 2 at the boot prompt for Extended BASIC. At the BASIC prompt, enter the command:

```
> OLD CS1
```

From the main menu, choose Disk > Tape > Load/Rewind Tape. Select your WAV file from the file browser and click Open.

Press Enter for both the prompt that will say, 'REWIND CASSETTE TAPE THEN PRESS ENTER', and, 'PRESS CASSETTE PLAY THEN PRESS ENTER'.

You will now hear loading noise, followed by a beep once it has finished. It then says 'PRESS CASSETTE STOP THEN PRESS ENTER'. You don't have to press 'Stop Tape' in the Tape menu, but press Enter nonetheless.

Now at the BASIC prompt enter:

```
> RUN
```

If the gods are smiling, your cassette file has loaded.

Loading disks

Loading disks on a TI-99/4A can be a nightmare. We didn't get file managers to launch executables but found a way of loading software from disk.

1. **Load your disk image** we'll use drive 2, as that gave us the best results. Click Disk > DSK2, then click the first menu entry. Then, choose your Disk Type from the drop-down menu, and click the button at the top-right corner to open a file browser. Click OK when you're done.
2. **Load the TI Workshop cartridge**, under Cartridge > Apps > TI Workshop (379). After the reset, press 2 at the boot prompt to load TI Workshop.
3. **At the TI Workshop menu**, press 3 for Disk Manager, followed by 1 for File Utilities.
4. **At the Disk Number prompt**, enter your disk number: we're using 2.
5. **If it has read the disk image successfully**, write down the names of any programs, which will be marked by the column on the right.
6. **Insert the Extended BASIC cartridge**, under Cartridge > Apps > Extended BASIC. Click Yes when prompted to change cartridge and reset the emulator.
7. **Press 2** at the boot prompt for TI Extended BASIC.

At the BASIC prompt, enter the command:

```
> OLD DSK2.GOLF
```

We're just using GOLF as an example, but replace GOLF with whatever filename you wish to load.

After a brief pause, enter:

```
> RUN
```

NEW AUSTRALIA UPDATE KICKS OFF A BIG YEAR FOR *MICROSOFT FLIGHT SIMULATOR*

DLSS support is also coming.

Microsoft Flight Simulator has received a handful of impressive world updates since its 2021 launch. These apply more detailed, handcrafted models to the otherwise procedurally generated map data, so that when you fly over Rome, for instance, you'll actually see famous landmarks rather than what the game thinks is there based on the data it has. In February, Australia got the world update treatment, and the list of landmarks it adds is truly impressive.

Alongside the obvious additions, like a properly fleshed out rendition of Sydney, the Opera House, and the Harbour Bridge, more regional locations are also fleshed out. These include smaller points of interest including the Great Barrier Reef, Mount Wellington, the Three Sisters, and more. New photogrammetry cities have been added (basically: more accurate, true-to-life versions) including Adelaide, Melbourne, Brisbane, Perth, Cairnes, Townsville and a bunch more.

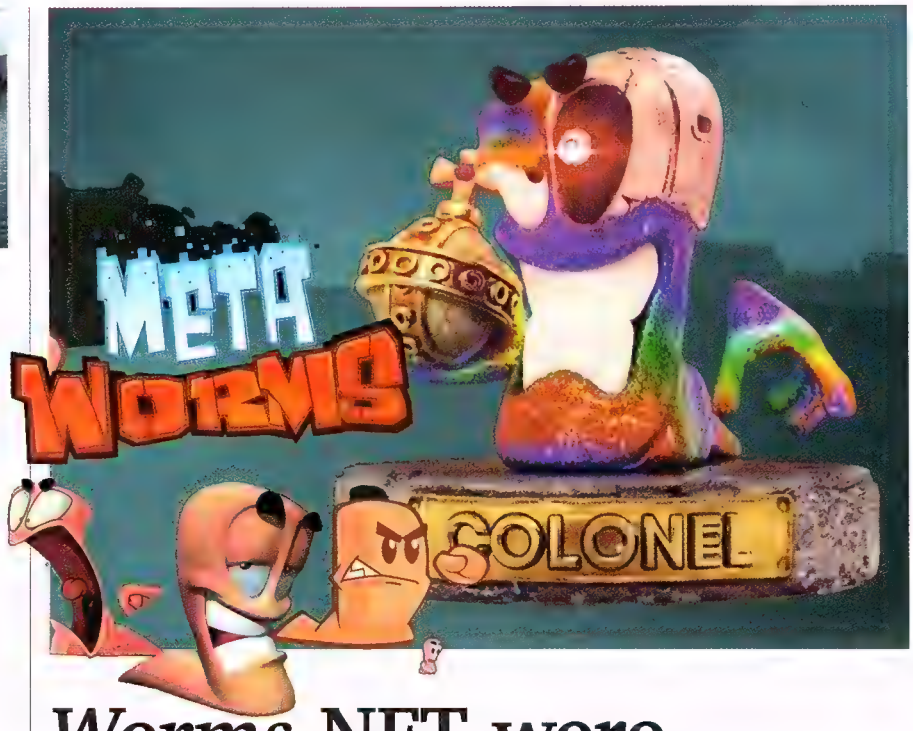
The update is available as an optional download when you boot up *Microsoft Flight Simulator*. On the performance front, you should expect greatly improved framerates in *MS Flight Sim* later this year when Asobe Studios rolls out DLSS support, joining AMD's FSR as another way to get the resource-intensive sim running smoothly on your PC.

THE NEW YORK TIMES BUYS *WORDLE*

It sold for a vague "seven figure sum".

Wordle creator Josh Wardle has sold his game to the *New York Times* for a price "in the low seven figures." It'll join a long list of games already available on the *NYT* website, including newspaper mainstays like crosswords and *Sudoku*, as well as *Tiles*, *Vertex* and *Spelling Bee*.

While *Wordle* will "initially remain free to new and existing players," the "initially" is telling, though it's unclear how it'll be monetised in the long run: games on the *Times*' site all have their own pricing structures. For example, crosswords require a subscription, *Sudoku* is free, and other games like *Letter Boxed* allow a single play per day. *The Times* definitely intends to make money off it, though: it was purchased in a bid to drive digital subscription numbers up to ten million by 2025.



Worms NFT were briefly a thing, before Team17 backtracked

Publishers and audiences continue to fight against the controversial movement.

The games industry continues to dabble with non-fungible tokens, the blockchain technology designed to apply value to digital goods. Ubisoft has dabbled, EA has considered it, and every time audiences have lashed back on social media, due to its inherent environmental dangers, as well as its popularity among scammers. The latest move into the space by publisher Team17 saw a very quick about face, after it announced its intention to issue a *Worms*-themed NFT.

Team17 announced the MetaWorms NFT project on January 31, which immediately sparked an outcry not only among audiences, but among Team17 development teams as well. In less than 24 hours, the publisher had withdrawn its plans. "We have listened to our Teamsters, development partners, and our games' communities, and the concerns they've expressed, and have therefore taken the decision to step back from the NFT space."

MICROSOFT BUYS ACTIVISION, BUNGIE GOES TO SONY

The consolidation of the games industry picks up pace.

Normally a quiet month for the industry, January saw two bombshell acquisitions, with Microsoft announcing its intention to purchase Activision-Blizzard for an eye watering US$68.7 billion. That means the Xbox company will own popular franchises including *Call of Duty, World of Warcraft, Hearthstone* and more.

Sony threw its own hat in the ring later in January, with the announcement of the $3.6 billion acquisition of *Destiny 2* studio Bungie, who also created Microsoft's *Halo* series. While hardly as impressive as Microsoft's Activision-Blizzard win (not to mention its 2020 acquisition of Bethesda), Sony Interactive Entertainment CEO Jim Ryan said more acquisitions are afoot. "We are by no means done," he told *GamesIndustry*. "With PlayStation, we have a long way to go."

NEW STUDIO FROM *XCOM* VETERANS WANTS TO "BLUR THE LINE BETWEEN STRATEGY AND ACTION"

It has big ambitions for strategy games.

A new studio built by *XCOM* studio veterans aims to "blur the line between strategy and action" games.

Bit Reactor founder Greg Foertsch's most recent credits include working as art director on *XCOM 2*, though his history with Firaxis stretches all the way back to its beginnings in 1996. The studio recently unveiled its official website and social media channels, and while it isn't ready to share what its first project will be, Foertsch outlined some of the studio's ambitions in a *GamesIndustry.biz* interview.

The short version is that those ambitions are very, very big. Foertsch expects Bit Reactor to "go head to head with *Halo* or whoever is out there, just like we did in 2012" with *XCOM*. He believes strategy games still have a massive amount of untapped potential to appeal to players of all stripes, not just the 4X hardcore.

"There are ways to tell stories and convey information that doesn't require a wall of text," Foertsch said. "That's what we're focused on – bringing that to the genre, and really blurring that line between what a strategy game is and what an action game is."

STEAM DECK VERIFIED GAMES NOW INCLUDE *HOLLOW KNIGHT*, *PSYCHONAUTS 2*, *SEKIRO*, AND MORE

But there's now a list of incompatible titles.

In January, SteamDB posted a tweet revealing there to be a confirmed total of 38 games submitted to the Steam Deck Verified program. That list includes some excellent titles like *Celeste, Cuphead, Hollow Knight, Sekiro: Shadows Die Twice, Psychonauts 2, Death Stranding, The Binding of Isaac: Rebirth, Dark Souls 2* and *3, Into the Breach*, and more.

All things considered, this is a pretty stacked line up for the Steam Deck Verified program right now, especially considering that this is merely the first wave of confirmed games. Last week, you might recall that Valve's own *Portal 2* became the first Steam Deck Verified game, officially making it the first game to be fully compatible with the new handheld device.

That is, simply put, what the Steam Deck Verified program amounts to: a game working perfectly with the new device from Valve. Being certified within the program means there aren't any limitations, technical or otherwise, to the specific game running on the Steam Deck, and you can run the stated game whenever and wherever you want.

LEGO STAR WARS: THE SKYWALKER SAGA IS COMING IN APRIL WITH NEW COMBO AND COUNTER DRIVEN COMBAT

As previously leaked by a retailer, the long-awaited *Lego Star Wars* game is set to arrive on April 5 across PC, PS4, PS5, Switch, Xbox One, and Xbox Series X and S. *Lego Star Wars: The Skywalker Saga* was initially planned to be released in 2021 (at least according to a leaked Lego Store page), but was subsequently delayed to 2021 then spring 2022.

CUSTOMISABLE PRONOUNS ARE COMING TO *THE SIMS 4*

Shared in a *The Sims 4 Official Livestream* update, producer John Faciane and experience designer Alister Lee demonstrated a work in progress build of the new pronoun options. According to Faciane, the team at Maxis worked with a partner from the It Gets Better Project to help advise the team on gender-neutral language. ■

The only thing missing from this boating trip is a couple of fishing poles.

apc EDITOR'S CHOICE

$74.95 | PC, PS4/5 | Steam

God of War

The best version of a masterpiece.

If you skipped the PlayStation release, or haven't touched the series at all, this is the *God of War* to play. All you need to know going in is that Kratos was Athena's best murder man until he was betrayed and decided to kill all of the gods (including his daddy, Zeus). This soft reboot picks up years later. In that time, Kratos left a now-godless Greece and wandered into the Norse lands, where he gained a wife (who has just passed away at the start of the game), a son named Atreus, and a glorious beard.

God of War has its restraint. It's a small story in a world of gigantic characters. Kratos and Atreus aren't out to save the world – they just want to spread their wife/mother's ashes on top of a big mountain. They're not actually looking for a fight, but end up walking into a bunch of them because, apparently, Midgard has been a nightmare land of evil trolls, poison witches, and zombies for the last century or so. Much of the game is basically carving a path through this broken world and, unravelling the petty god drama that led to its ruin.

There's a lot of *The Last of Us* and *Uncharted* in its puzzly moments – hoisting young Atreus up a ledge to kick down a rope and jostling dilapidated supports to make a bridge are pages straight out of the Naughty Dog playbook.

For as good as *God of War*'s characters and stories are, my strongest memories all revolve around one of the greatest weapons in videogames: the Leviathan Axe. The axe is your primary weapon and do-it-all multitool throughout the entire game. It can pry open doors, destroy obstacles, freeze machinery in place, or be thrown the length of a football field to nab hard-to-reach loot. In combat, the Leviathan Axe is a gratifying balance of heft and speed that hits a lot harder than Kratos' old Blades of Chaos. Here, again, Sony Santa Monica leverages Kratos' supernatural might to let you do impossible things with an axe, such as cleaving three enemies in half with a single crushing move.

Then there's the Leviathan's other perk. You've probably seen cool gifs of Kratos throwing the axe at a draugr and recalling it back to his hand like Thor's hammer. It feels just as cool as it looks and doesn't stop being cool for dozens of hours.

It's exciting to think about what *God of War*'s landing on PC could mean for the console exclusive status quo. Sony has a dedicated PC publishing label now. As it gets more serious about PC ports, will we ever get to the point where its games release on PC months after launch instead of years? That's probably a stretch, but *God of War* is a great sign.

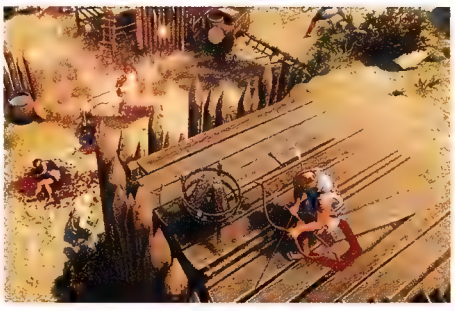
Atreus will automatically help Kratos in a fight with arrows, grabs, and special stun moves.

One of the best games on PS4 is now one of the best games on PC. A masterful, cinematic adventure.

Morgan Park

★★★★½

THE EGYPTIAN QUEEN
CLEOPATRA: Time to get to the point? No more foreplay?
1.
2. If you please.
3. I have a particular dislike for idle chatter



$64.95 | PC | Steam

Expeditions: Rome

Rome wasn't built in a day, but did it really take this long?

Expeditions: Rome is a historical RPG with elements of strategy that sees you conquering much of the classical world while navigating high-level Roman politics on the home front. Fiddly RPG traits like levelling, trade and inventory management are simplified, which you may be grateful for in a game that still manages to clock in at 70-plus hours.

You'll spend much of the game running around with six companions. There's enough banter between these ragtag Romans to build up some fondness for them, but unfortunately their sidequests – like most sidequests in the game – struggle to squeeze in around the main story, like jam barely clinging to the edges of an overstuffed sandwich.

In fairness, there's little time for getting cosy with companions when you've got an entire Roman legion to manage. As a member of an esteemed Roman family under threat from a powerful senator dead set on your extinction, you get shipped out to a Roman army trying to retake Asia Minor. Before long, you rise to the position of legate, commanding a thousands-strong Roman legion while running around with your crack squad on clandestine missions like assassinations, disrupting enemy supply lines and trying to expose the corruption of the rival Roman family out for your head.

A good part of the game is spent on an overworld map, from which you can send your party of praetorians and your army on missions around the land. You use the legion to take over the map and procure resources for upgrading your encampment with things like barracks, a forge and a bath house, where stationing a praetorian with the 'Social' trait will steadily increase the morale of your legion.

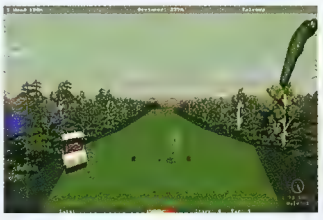
The legion battle system through which you take over large chunks of the world is rather simplistic, and once I realised it was little more than a numbers game I'd simply auto-resolve battles. The meatier portion of the game is spent with your party of praetorians, with whom you get to explore cities, chat to NPCs and engage in turn-based combat.

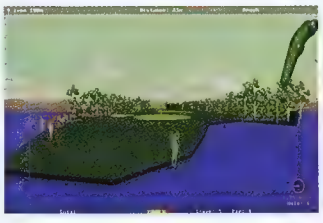
Top: Cleopatra's appearance sticks with the pop-culture image of her as a master seductress. **Above left:** The turn-based combat is intense and not always forgiving. Have that quick-save finger primed. **Above:** Use legion encampments to replenish your armies, treat your praetorians and upgrade your weapons.

An uneven epic whose historical richness guides it through some awkward pacing while playing.

Robert Zak

★★★☆☆





Free | PC, Mac, Linux

VGA GOLF

Taking this retro-styled game for a test drive

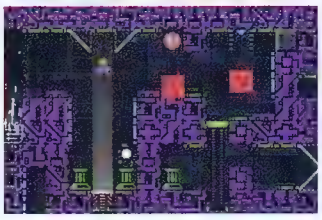
VGA Golf taps into my old-man nostalgia for the days of low- poly 3D and poorly digitised sound clips. It uses a traditional on-screen swing-o-meter, you line up the direction of your shot (while accounting for the wind); you tap the button to start your swing, then stop it on the swing-o-meter to decide its power. There are a couple of extra steps to decide the angle, and type of club you'll use, but playing the game is simplicity itself, despite a dated aesthetic that perhaps suggests an old-fashioned fustiness.

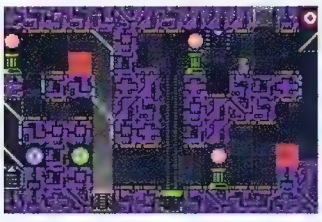
It walks a fine line between simulation and silliness, in a way that I find appealing. Here you can swap golf balls for miniature snowmen, flower pots and planets. I had fun creating characters vaguely based on those part-time putters Mario and Luigi. But the best thing about *VGA Golf* is the atmosphere of the course, the quiet ambience as you plan and execute each swing. The calming background audio is perfectly placed, as are the sudden, compressed sound clips of the very '90s announcer.

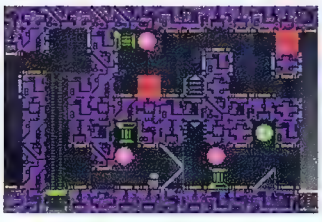
A basic yet full-fat golf game that offers a focussed game of golf, uncluttered with alternate modes.

Tom Sykes

★★★★☆







Free | Browser
benjames171.itch.io

PATHFINDER

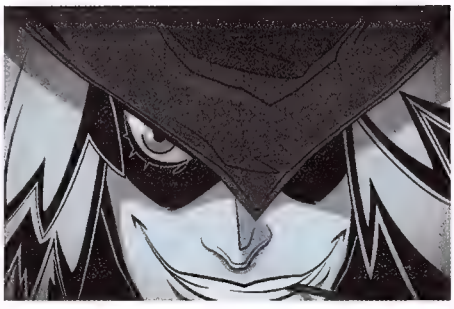
Solving puzzles by shifting balls.

Pathfinder's central mechanic is one I've not seen too often: it's a puzzler in which you guide glowing balls of light around, to activate switches. As a little green person, you have to leap around, push crates and fiddle about with mirrors, all to get the balls to go where you want them to. The order is the most important thing. It had me restarting each stage a number of times. You need to shift that crate to the teleporter, but before you activate that ball, so the crate doesn't block its programmed path.

Stages are manageable enough that I was able to sustain the puzzle in my head, chewing it over while my hands mechanically tested my theories. It's a Goldilocks puzzler for someone who likes puzzle games, but whose brain nopes out at the more extreme entries in the genre.

With its small scope – not to mention its wonderfully warbly chiptune soundtrack – *Pathfinder* feels like it should come packed on a floppy disk with about 100 other forgotten little games.

Pathfinder offers a lunchtime's worth of testing fun.
Tom Sykes
★★★½☆



$21.50 | PC, Mac | wolfstridegame.com

Wolfstride

Cheap humour betrays its smart storytelling and intriguing setting.

Top: The story never quite finds its tone...
Above: ...but it's full of likable, weird characters.
Above right: That's the face of someone up to no good. With mechs.

Wolfstride from Ota Imon is a self-described RPG for grown-ups that wallows a bit too frequently in immature humour. It never fully builds on its narrative promise, but the setting and cast make it a spin on an often stagnant genre.

With its dramatic opening, you'd be forgiven for thinking *Wolfstride* was faster paced than it is. The curtain first rises on a mech battle where your loveable but doofy pilot Knife Leopard faces off with team leader Shade against a hardened criminal type in a rigged robot fight

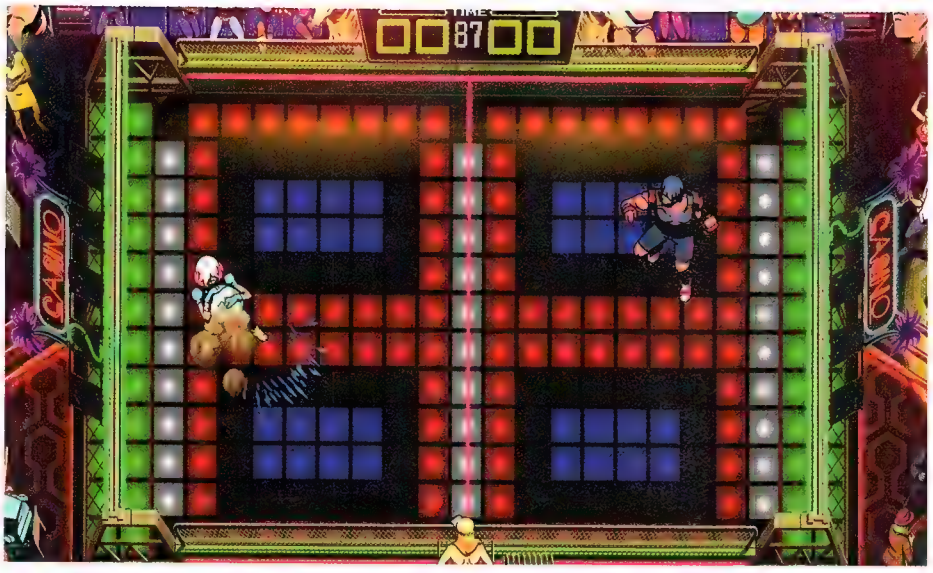
That's as much action as you'll see for a long while. Shade and friends settle into a routine of exploring Rain City and desperately throwing themselves at any opportunity to earn money. You have 63 in-game days to fix your shattered mech Cowboy and prove yourselves in another match. But the way *Wolfstride* gradually rolls out its story means much of that time feels like it's not well used.

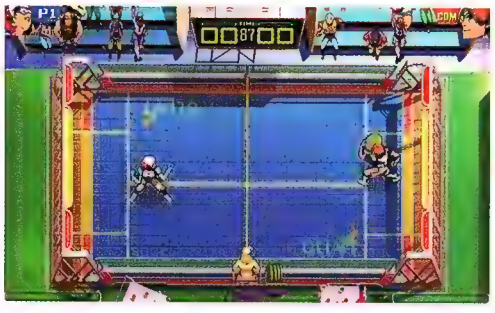
Shade gets access to a few part-time jobs eventually, which function as money-earning methods as much as they do ways to break up the repetitive action. While the goal is pouring that cash back into Cowboy for arena fights, *Wolfstride* is a visual novel about a group of shady middle-aged heroes down on their luck more than it is an action-packed RPG.

The thing is, *Wolfstride* is never sure what to do with itself, and leans too heavily into the 'immature' part of its 'immature grown up RPG' tagline. Every time I started settling into the story, Wolfstride threw something ridiculous and unnecessary at me.

While the mech fights aren't as detailed as some, there's a solid combat system. *Wolfstride* makes you balance between brute force and carefully planned defence in a continuous dance of give and take. The only downside is you see most of what *Wolfstride* has to offer early on. *Wolfstride*'s combat is as fresh as its take on RPG casts, and I hope Ota Imon gets the chance to create a more expansive system in the future.

Ota Imon has something interesting to say with *Wolfstride*. I just hope it finds the right voice to say it with next time.
Josh Broadwell
★★★☆☆





$TBA | PC, PS4/5, XB1, Switch, Stadia

Windjammers 2

To Frisbee or not to Frisbee.

No surprise if you've never heard of the original, there's been over two decades between its release and this sequel. The fundamentals of the two are more or less the same. Not just in its controls and design but in the throwback vibe of its aesthetics too. While it's no longer in 8-bit, these slick hand drawn looking sprites capture those same bold colours to convey an idolised '90s feel good world where the sun is always shining and we're all here to have a good time.

Matches are straightforward, each round you're served a Frisbee with points attached to it which are awarded to the first player to either hit their opponent's back wall or make them fail to catch it. Specials allow you to knock through opponents defences or move the Frisbee faster but the depth comes from all the various ways you can curve your throw or build up speed with ricochets or counters. Even on the easy difficulty setting, there is a steep learning curve here and you'll need fast reaction times to stand a chance.

When you master it though, its rapid pace is enthralling. When you start you'll be making basic throws and managing little back and forth but soon, games become a frenzy of countering and special moves. You have several superstars to play as, all in delightful costumes with over the top, heavy duty protective gear. They each have varying levels of power and speed, determining their throw and movement respectively, as well as unique special moves which are really only discovered through play.

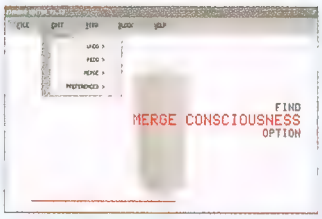
At the right price it's just fine for those looking for a little novelty arcade experience with pals but there's little here besides. Hardcore *Windjammers* fans will probably be able to mine the nuances of its simple mechanics for maximum depth, and while there's plenty of style to soak up there's little of real value to hold attention for more than a couple of hours.

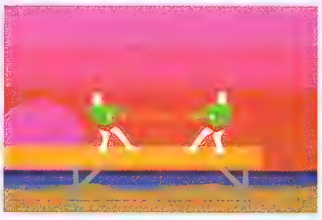
A stylish arcade throwback that delights while it lasts but sadly has little to offer in the long run.

Samantha Greer

★★★☆☆

Top: You get to compete in a range of increasingly absurd locales including this casino.
Above left: Anticipating your foe's next move is the key to staying ahead.
Above: The game is seldom less than totally OTT.





Free | Nrowser
dreyan.itch.io/jingoku

JINGOKU

Wario has nothing to fear.

Where WarioWare is characterised by its anarchic pixel art and gleefully childish sense of humour, *Jingoku* is more understated, minimalist, and dare I say classier, its assortment of timed microgames including plenty of silly scenarios – but no nose-picking. Instead, you're *Flappy Bird*-ing a paper aeroplane, you're playing tug-of-war, and hurling a pesky hat onto a hat rack.

But while Nintendo's classic series offers a mixture of tough and easy games, I was only ever able to scrape together a few successes in *Jingoku*. It might be that the time limit is stricter, or it might have something to do with this game's less responsive control systems, which are not explained before you're thrown in at the deep end.

With scant few seconds on the clock, I feel that movement should be instantaneous, or at least consistent across the microgames, but I failed so many scenarios here because I was still getting used to the controls. There's very often a slight delay between your input and the character's actions, and no time to get a feel for how long that is.

Too frustrating and too little reward.

Tom Sykes

★★★☆☆

GAME CHANGER

Crimzon Clover

Will Freeman revisits a shmup that rivals the genre's best.

RELEASE 2010 **DEVELOPER** Yotsubane **PUBLISHER** Degica **LINK** degicagames.com

Back in 2011, the global shmup community was awash with murmurings about a new creation within Japan's 'doujin' hobbyist game development scene. Its name was *Crimzon Clover*, and after a complete build first appeared at a Japanese fan convention in the closing days of 2010, a swirl of rumours suggested that it was very special indeed.

Fortunately, it turned out that the speculation was spot on. *Crimzon Clover* takes the form of a typically frenetic bullet hell shmup – or shoot-'em-up, to use the more traditional term – and it does it very well indeed. Like many of the best shmups, it blends a hyperactive, overwhelming pace with tremendous scoring depth, and is challenging, rewarding and wildly exciting in equal measure. If you're imagining sweeping, terrifyingly dense bullet patterns realised in neon colours that intersect as a player ship weaves through unfeasibly small gaps while gunning down a barrage of enemies, you have exactly the right type of game in mind.

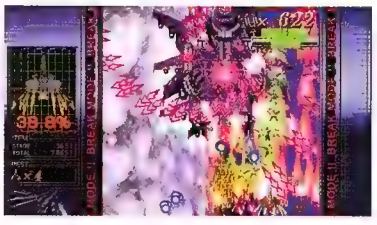
And it is available to play once more. At the close of last year, doujin studio Yotsubane's creation arrived on Steam under the title *Crimzon Clover: World EXplosion* – given a thorough polish and a range of new and tweaked modes. Its return made it hard to resist pondering the mystique around the original release, and just how well this hobbyist curio turned cult hit holds up today.

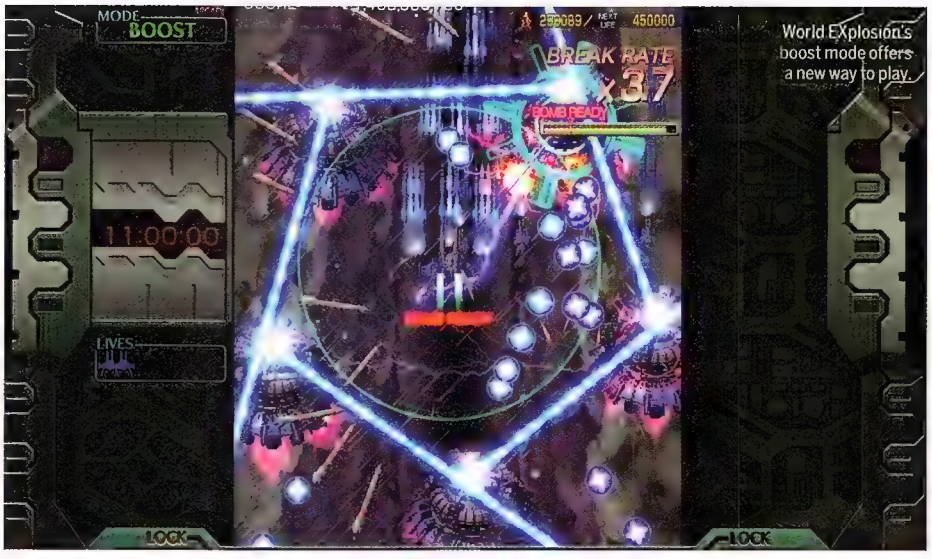
Origin story

It's worth noting here that *Crimzon Clover*'s distinct origin story was a huge part of its appeal, all those years ago. But surely that element of a game's appeal fades with time? Or perhaps not…

The developer Yotsubane is better known in arcade circles as CLOVER-TAC, a longstanding serial shmup world record holder and certainly one of the genre's best players. Before making his own game he had previously served as a playtester for Cave, the pioneering bullet hell studio, famed for the difficulty of its games and the depth of its fanbase's pockets. CLOVER-TAC had the skills to test the upper limit of those games – and now he was taking what he learned as an elite player and tester, and applying it to his own creation.

There was also something else about this hobbyist homage to genre greats like DoDonPachi that made it atypically alluring. Conventional thought states that for maximum credibility and authenticity, a shmup should start out as an arcade release. And yet here was a shoot-'em-up initially only available as a boxed PC release; a PC release so popular with genre devotees that it

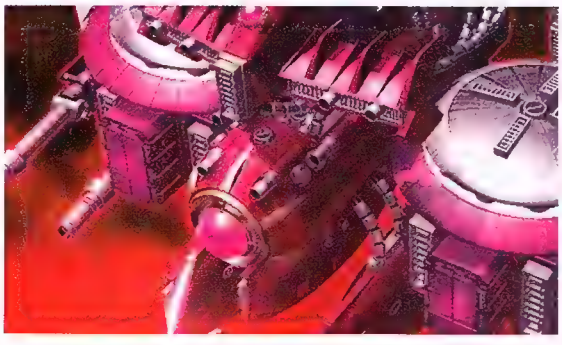




World Explosion's boost mode offers a new way to play.

LEFT: Hoovering up point items never fails to be satisfying, whichever version you play.

ABOVE: Bosses and mid-stage bosses are where the most intense battles lie.



achieved the unthinkable, and was ported to arcade cabinets in 2013. There had been other doujin shmups on Japanese PCs before, including the popular Touhou series. But those games were so distinct from the design and playfeel of arcade shoot-'em-ups they can arguably be classed as a distinct sub-genre in their own right. *Crimzon Clover*, meanwhile, plays every bit like a purebred intense arcade shooter; something strikingly apparent today.

It was also rather tricky for Westerners to even try the game – typically requiring a contact in Japan who could get it directly from CLOVER-TAC at a convention, or from one of four official stockists.

I first came across the mysterious shooting game when a fellow player bought a laptop and copy to London's confusingly-named Casino arcade; then a shoot-'em-up haven with an enthusiastic crowd of regulars who would lend their own arcade PCBs to the collection of aggressively well-loved, geriatric cabinets. The laptop was placed on a pool table, and we prayed that the arcade's owner wouldn't quickly eject us for evading the need to spend money in his establishment.

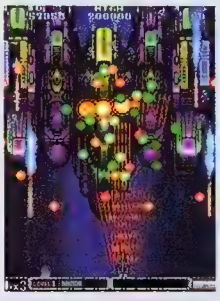
Everyone packed into the basement was quickly captivated. For all their efforts, the surrounding arcade cabs spewing demo modes in slashes of neon and rasping bleeps could not drag attention away from what was happening on the pool table. That modest machine brought from Japan had broken into the inner sanctum of arcade gaming, and was quickly proving a coin slot isn't essential for quality shmup play.

Old school flavour

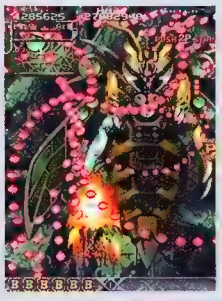
All of that made *Crimzon Clover* feel so special back then. What is remarkable all these years on is that the story behind *Crimzon Clover* still brings something distinct. And that becomes apparent when you fire it up once more.

Loading up the game today, I

BULLET HEAVEN *The icons that shaped Crimzon Clover*

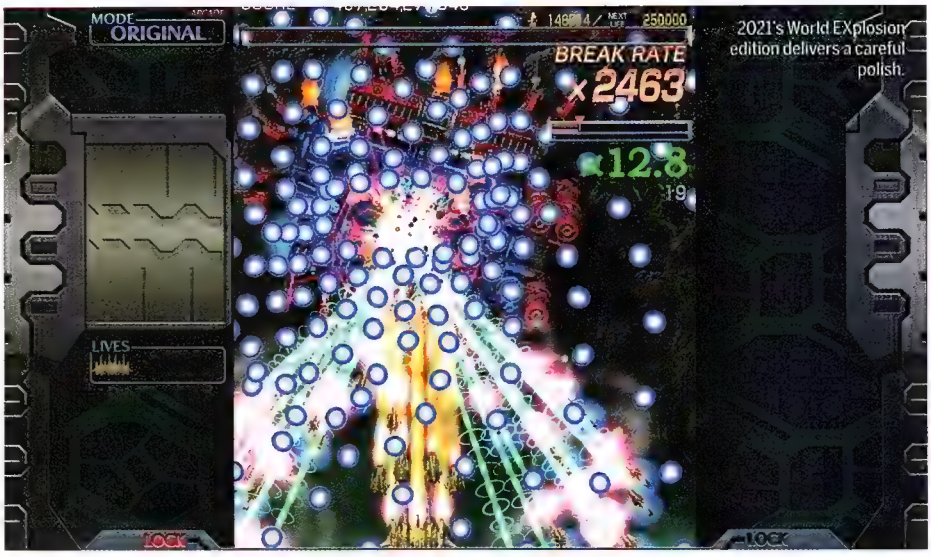


BATSUGUN 1993
Arguably the first ever bullet hell game, from one of the shmup genre's most important studios, Toaplan.

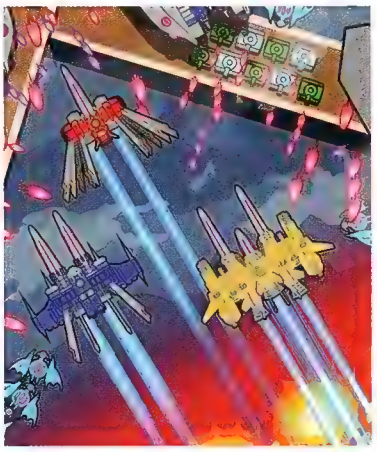


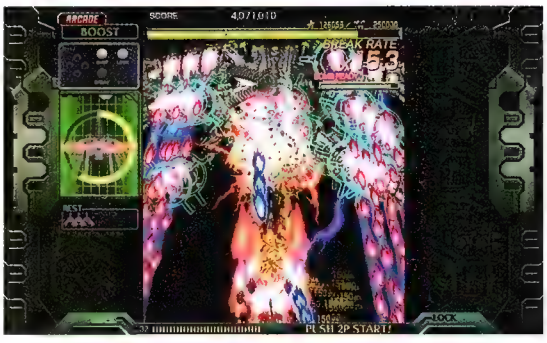
DODONPACHI 1998
Perhaps the most defining bullet hell game there is. The sequel *DoDonPachi Resurrection* is on Steam.

KETSUI 2003
Also from Cave, *Ketsui* offers a brutal experience that somehow demeans and delights in equal measure.



2021's World EXplosion edition delivers a careful polish.





ABOVE: The decidedly retro poster promoting *Crimzon Clover*'s 2021 PC return.

RIGHT: Unleashing a 'Break' weapon power-up sits at the heart of the scoring.

braced myself to be reminded of the difference between warm nostalgic memories and timeless game design. And yet, here in the light of 2022, *Crimzon Clover* continues to defy expectations. As the work of a hobbyist going up against deeply experienced shmup studios, it quite simply shouldn't have felt so splendid in 2011; let alone a decade later.

Firing up the game's vanilla mode, it immediately packs a visual punch all these years on. Despite moving with significant pace and energy, *Crimzon Clover* remains bristling with detail that does much to convince that the setting really could be a complete, living place with much more going on 'off camera'.

Of course, here in 2022, modern shmups tend to very much trade in the currency of nostalgia. All of the newly made crisp pixel art and crunchy retrospective audio present today might mean we've grown used to decidedly modern releases bringing a deliberately old-school flavour.

That might work in the original *Crimzon Clover*'s favour – today retro game art can feel very much contemporary. But without doubt, *Crimzon Clover*'s visual elements do not absolutely confine it to the retro past.

Working your way through the original game's three modes, it is evident that Yotsubane delivered something that transcends the quality of a great many doujin works, including those made today.

This is where the origin story comes in. Coming from the position of being a deeply experienced consumer of the genre, and spending five years working on the game in his spare time, TAC built a shooter that makes it hard to resist the cliché that is a game being 'a love letter to its genre'.

And yet, even by his own confession, that is what Yotsubane endeavoured to craft. All these years on, his letter reads like a heartfelt devotion to how wonderful 2D shooters can be, written in screens that are consistently packed with enemy firepower, clusters of score-boosting 'gems', and torrents of cascading numbers.

Crimzon Clover scoops up the best of titles like *DoDonPachi, Mushihimesama, Ketsui* and *Espgaluda*, and reimagines them from the player's perspective. The result is something that still feels distinct, and that toys with expectations around how these games work.

It is every part a game informed by being an avid consumer of shooters, and understanding the appeal that hides behind the most apparent gameplay; dodging and shooting. It also achieves something the best shmups commonly fail at.

AN EXPLOSIVE RETURN

What does the 2021 version offer?

1 The visuals have undergone a generous polish, neatly capturing the original style while bringing it forward.

2 *World EXplosion* gives you a wealth of variant arrangements, upping the variety the package offers.

3 While the enemy firepower will keep coming for you, you'll find ways to make them vanish in a moment.

What lurks beneath

To be besotted by shmups is to love what lurks beneath the screen – a dance with entangled multipliers and combos, all tied up with deliberately obscure scoring systems, weapon behaviours and playstyle. Therein lies that magic of the form – and the very element that makes it so impenetrable to so many.

Yotsubane's greatest achievement with *Crimzon Clover*, then, is in making a shooter that is authentic and challenging enough for genre obsessives, without ostracising the great many players who simply want to experience the thrill of bullet hell without giving over every moment of their gaming time to practice or scoring strategy development.

For example, *Crimzon Clover*'s approach to player life stocks still feels striking and effective. In a genre where extra lives are a deliberately limited entity, *Crimzon Clover* lets you pick between a score boost or a life at the end of every level. Making it possible to gain so many lives simply shouldn't work. To be so well stocked in additional tries is arguably undermining the drama and challenge that comes from lives being a tremendously precious currency.

But, by employing his players' perspective, Yotsubane identified an opportunity to deliver a true shmup that would satisfy two audiences. To place highly on the leaderboard, you'll need to select the score option every time, limiting lives and keeping the experience a challenge for the masochistic. But if you want to just taste an authentic bullet hell rush without relying on stripped back easy modes, the option to pick up so many lives delivers a fine balance of intensity and approachability. In fact, on reflection it feels rather curious that we haven't seen more shooters adopt such a cunning and understated innovation. It may not be an exclusive feature of *Crimzon Clover*, but it feels like it should be much more common.

Convention at its best

Ultimately, *Crimzon Clover* obeys a familiar design philosophy in a genre deeply constrained by convention. And yet the best shmups stand out by being creative and nuanced within those constraints – something *Crimzon Clover* does with aplomb. It remains as exciting and dynamic today as it did at launch. It boasts a generous capacity for fostering different playstyles and approaches, and has tremendous scoring depth. When you get even vaguely decent, it makes you feel like a much better player than you are – and that sensation never gets old. And if you're just passing by the genre and fancy a taste, it does a great deal to keep things welcoming.

It's hard not to love the fact that this hobbyist release took the PC to arcade gaming and triumphed and then some. Purists might tell you that the 2013 Japanese arcade release provides the best way to experience *Crimzon Clover*. If you've a love for arcade gaming it's tempting to take that position. But today so many arcades are sadly closed in the West. Casino went under the same year that Yotsubane's creation made it to cabinets.

Frankly, *Crimzon Clover* is a PC game first and foremost. It also happens to be one of the best shmups you can play on any format – as it was on launch, and as it is today. ■

CHIP CHAT

BEN MANSILL REPORTS ON THE UNUSUAL SIDE OF TECH NEWS

EXCUSE ME, HOW MUCH?

The $3,400 motherboard.

Don't buy that 65-inch OLED TV you've budgeted for, because Asus will take those beans in exchange for a new motherboard, instead. The Asus ROG Maximus Z690 Extreme Glacial shames the $1,000 boards we've been shaming in *APC* lately. A scan of the specs reveals bells'n'whistles galore, like 10Gb networking, Thunderbolt 4, five M.2 slots and war-grade power systems and components. There's also a little LED display. But most of the moola goes to the monolithic EK waterblock that cools just about everything, including the VRMs, M.2s, and the chipset. *APC* is pleased that such things exist in this timeline, even though we'll never own one.

RAZER ZEPHYR IS REALLY REAL, NOW

Looking sharp in the end of times.

Razer likes to do crazy weird radical projects, like its toaster – and its RGB facemask – which until now wasn't expected to actually become a real product. Well, now it is, and you can buy the new Razer Zephyr for US$100 from the Razer store online. Besides offering N95-levels of filtering, it has RGB, of course, and is controlled via a phone app – of course it is. It has built in fans that can run at two speeds, and battery life ranges between four and eight hours, depending on fan speeds and how much RGB is on your face.

Dancing routers

All hail the dawn of the motorised era.

While magazines are still winning the content wars vs the internet, sadly we cannot print animated gifs or videos. So you will just have to use your imagination as you picture TP Link's new Archer AXE200 Omni router wiggling its motorised antennas.

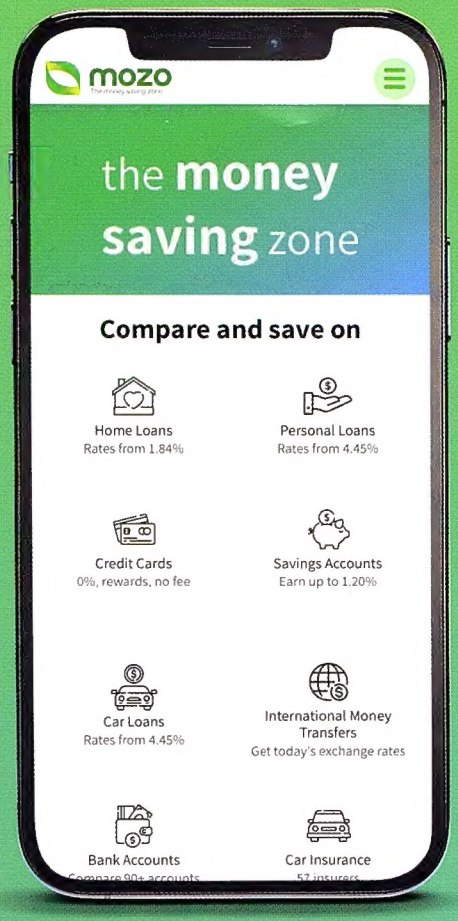
TP Link tell us this is so the antennas can orient automatically for the best signal. But we know 90 pecent of the truth is because it looks hella-cool. This is definitely a nuclear escalation in the router wars. Asus and the rest will all have to have motorised antennas now. They can't let this get away from them.

In meetings across Taiwan and China right now are labcoats shouting "what else can we motorise?" It's like the dawn of the RGB era. Expect more moving things. This is the way.

BEGUN IT HAS, THE MOTORISED PC

More whirly twirly moving parts.

And... we didn't have to wait long. US-based manufacturer CyberPower PC showed off its Wild Kinetic Case at CES this year. Unlike TP Link's mere four moving parts, this case ups the potential points of failure to a stupendous 18, being the number of individually controlled vents on the front panel. It does look delightful in action, and works by adjusting the openings based on case temps. Normal boring people will ask "why don't you just leave the front open, or behind a mesh?". But they haven't experienced the thrill of seeing all 18 little doobies swing open dramatically the moment you start a SuperPi run. ■



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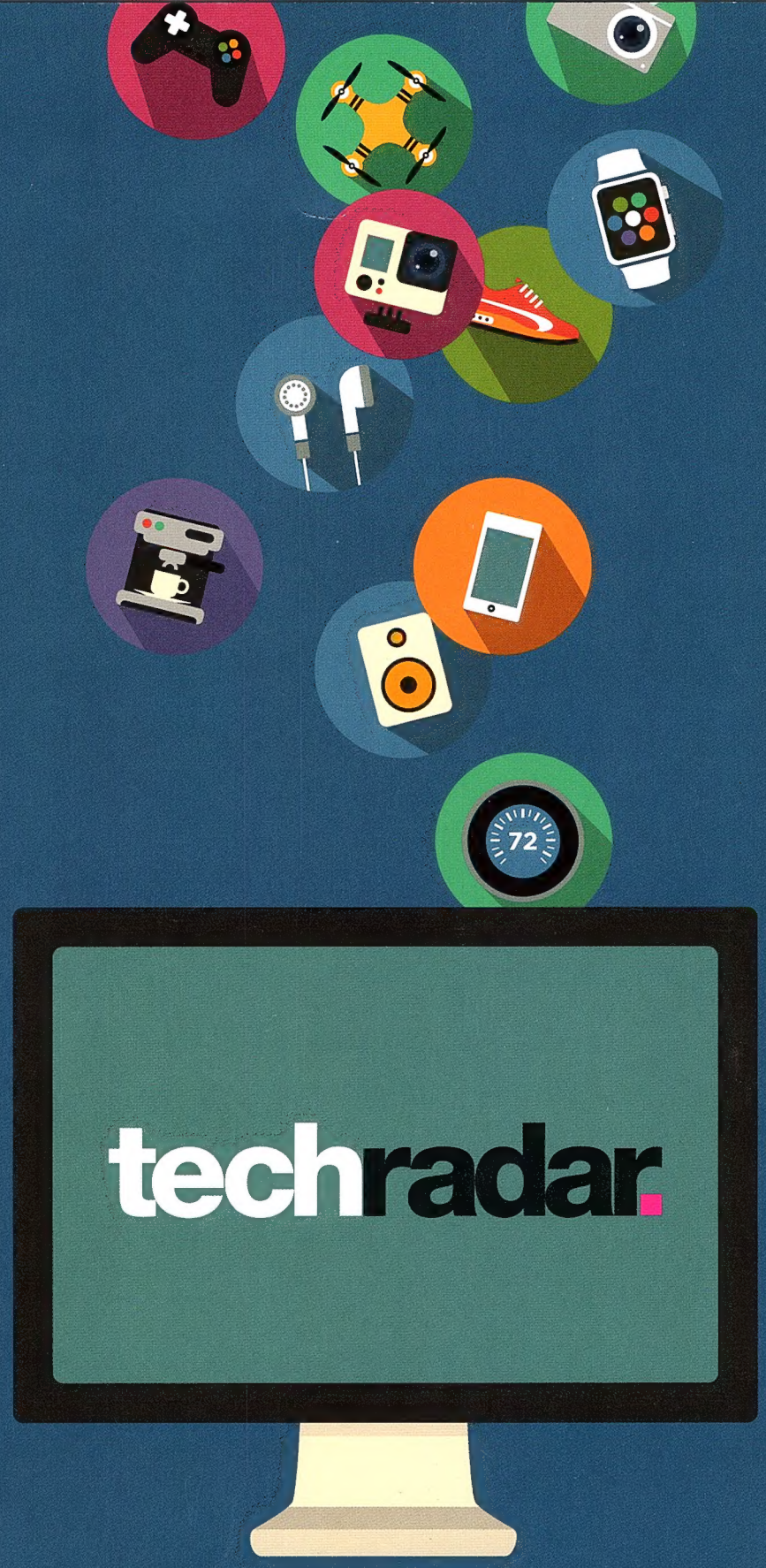

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